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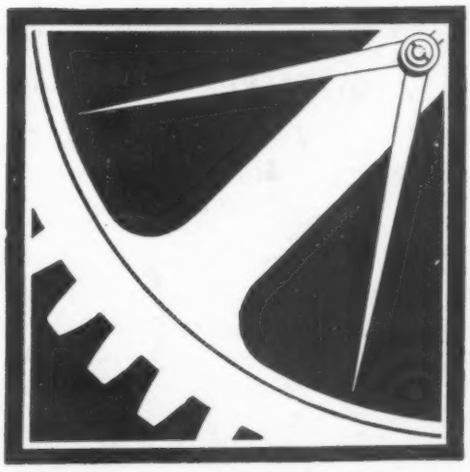
MACHINE DESIGN



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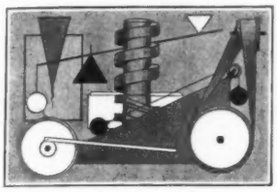
Volume 2 **February, 1930** **Number 2**



In This ISSUE

ELSEWHERE in this issue the statement is made that a consensus of opinion, following the recent automobile shows, indicates that the front wheel drive car and the new 16-cylinder Cadillac engine were the outstanding developments in the design of automobiles during the past year.

An earlier issue of MACHINE DESIGN *included an article on design problems encountered and overcome in the front wheel drive and on pages 28, 29 and 30 of the current number will be found a contribution dealing in general with the new 16-cylinder engine, and in particular with the unique design of the automatic valve clearance adjuster employed.*

L. E. Jermy.

Managing Editor

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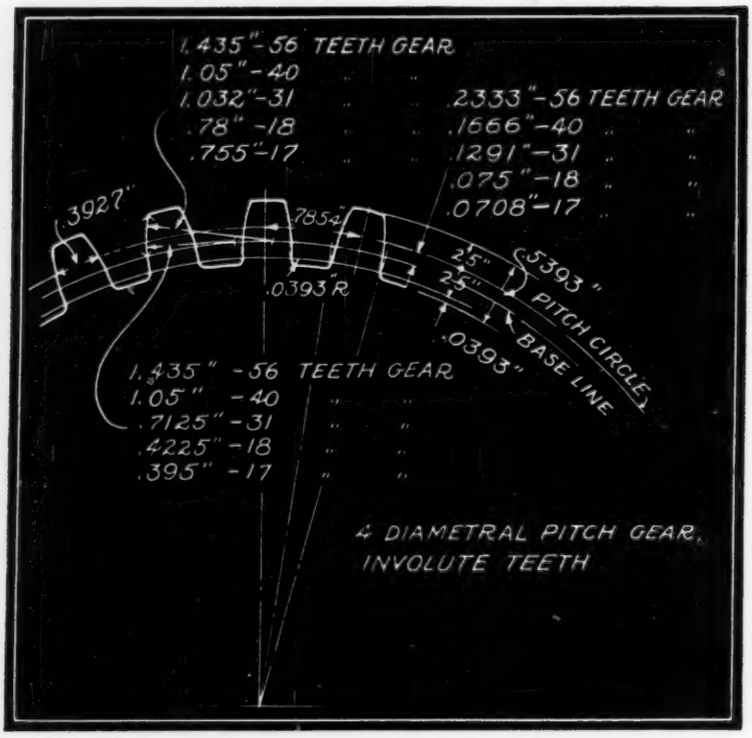

This emphasizes the fact that Fort Pitt co-operation is not merely idle talk, exaggerated claims or promises lightly made, but a reality, and indicates our ability to increase the quality while decreasing the cost of metal parts.

For example, while at first glance there is nothing unusual in the train of gears shown on the right, the history of these gears demonstrates very clearly how Fort Pitt accomplishes its aim "to reduce the cost of metal parts".

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2. **Inquiry turned over to Engineering Department (all inquiries receive their attention no matter how simple the job may appear).**
3. **Because our Engineers think in terms of parts, rather than tonnage, they looked beyond the gear blanks as such, and studied the gears and the use to which they were to be put.**
4. **After a careful consideration of all factors involved, they recommend that the teeth be cored instead of cut (Fort Pitt foundry methods would insure necessary accuracy).**
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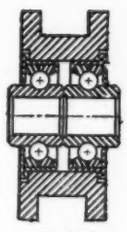

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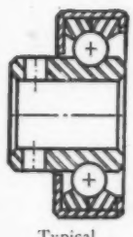


Typical Installation

BEARINGS

CALENDAR OF MEETINGS AND EXPOSITIONS

Feb. 15-23—International Aircraft exposition. To be held in the Arena at St. Louis. An exhibit of American and European airplanes, and principal aeronautical accessories, parts, and materials of construction including engines, starters, wheels, landing struts, aluminum alloys, steel balls, roller bearings, etc. Mounted instrument panel equipment for engine temperature indicators, magnetic compasses and other aircraft devices including airport lighting equipment will feature one of the operating exhibits. During the same week the Society of Automotive Engineers will hold its national aeronautic meeting, Feb. 18-20, at Hotel Jefferson, St. Louis.

Feb. 17-20—American Institute of Mining and Metallurgical Engineers. One hundred and thirty-ninth annual meeting to be held at Engineering Societies building, 29 West Thirty-ninth street, New York. The technical sessions of the Institute of Metals division and other sections of the organization will include papers of interest to the engineering profession. At the meeting of the technical committees a paper on the topic, "A Plea for the United States Court of Patents Appeals," will be presented by William E. and Kenneth W. Greenwalt. At the annual dinner at Hotel Commodore John Van Nostrand Dorr will be presented with the James Douglas medal and James Aston will receive the Robert W. Hunt medal.

Feb. 18-20—Society of Automotive Engineers. National aeronautical meeting to be held at Hotel Jefferson, St. Louis, during the week of the International Aircraft exposition. Five sessions, at which will be presented 12 papers devoted to aeronautical engines, fuels, instruments, production, etc. will be held. The engine session will open the technical meetings. Sessions are scheduled to begin at 10 o'clock each morning.

Mar. 3-7—National Industrial Equipment exposition. To be held at Hotel Stevens, Chicago. During the same period the National Management congress meets Mar. 3-5 and National Materials Handling meeting, Mar. 5-7. Features of the exposition will comprise new methods and advanced applications of materials, supplies and design of equipment for plant production and operation. Problems relating to transmission, materials handling, maintenance, operation, production and management will be discussed by competent engineers and executives. Displays by manufacturers will include gears, chain drives, shafting, transmissions, lubrication and bearings, and will emphasize important developments and progress in industrial endeavors. The exposition will be under the management of Midwestern Engineering exposition, 308 West Washington street, Chicago.

Mar. 5-7—American Society of Mechanical Engineers. Materials handling division of the society will sponsor third National Materials Handling meeting to be coordinated with Industrial Equipment exposition and National Management congress. Technical sessions will be held at Hotel Stevens, Chicago. Calvin W. Rice, 29 West Thirty-ninth street, New York, is secretary.

April 5-9—American Society of Mechanical Engineers. Fiftieth anniversary celebration. Opens in New York with a series of special events there and in Hoboken, where the society was founded. Sunday evening, April 6, special trains leave for Washington where headquarters will be located at Mayflower hotel, and meetings will be held in United States chamber of commerce building. The Washington program will be the main part of the celebration at which representatives of engineering societies from over the world will extend greetings. Sixteen national papers will be presented by leaders of the engineering profession from various countries. The session will be followed by conferring of honors upon a number of leading engineers. Calvin W. Rice, 29 West Thirty-ninth street, New York, is secretary.

April 5-13—All American Aircraft show. To be held in Detroit.

April 8-9—Society of Automotive Engineers. Technical meeting on aeronautics at Detroit.

May 12-16—American Foundrymen's association. Annual convention at Public auditorium, Cleveland. C. E. Hoyt, 222 West Adams street, Chicago, is executive secretary.

May 19-21 1930—American Society of Mechanical Engineers. Fifth national aeronautic meeting, Dayton, O., and Wright field. Calvin W. Rice, 29 West Thirty-ninth street, New York, is secretary.

May 29-31—American Electrochemical society. Spring meeting at Hotel Coronado, St. Louis. Colin G. Fink, Columbia university, is secretary.

June 9-12 1930—American Society of Mechanical Engineers. Fifth national aeronautic meeting, Dayton, O., troit. Calvin W. Rice, 29 West Thirty-ninth street, New York, is secretary.

June 23-27—American Institute of Electrical Engineers. Annual summer convention to be held at Toronto, Ont., Canada.

MACHINE DESIGN

February *1930*

The Time Is Ripe for Engineers To Consider the Human Factor

By L. E. Jermy

Managing Editor, Machine Design

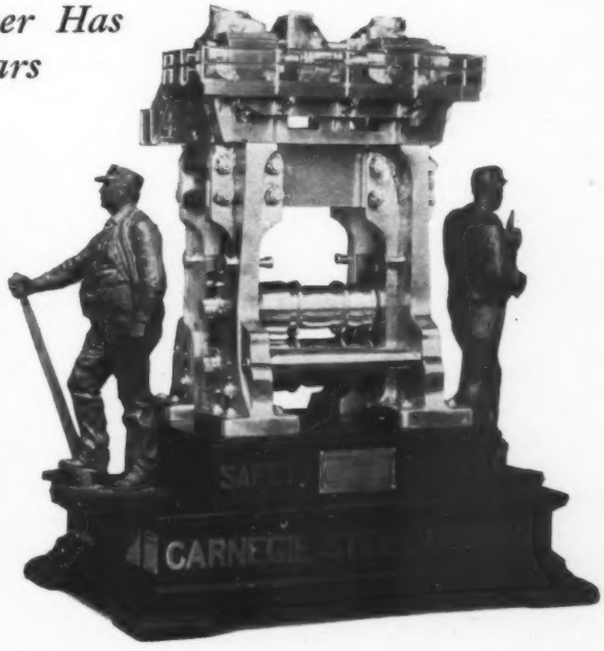
IT IS a curious fact that during the past decade practically every influence in the economic life of the nation—with the notable exception of the design profession—has contributed something openly and definitely calculated to glorify the American industrial worker.

Employment managers have tried to overcome the old evil of reckless hiring and firing. Economists and public officials have sought to stabilize employment. Health authorities and safety engineers have worked faithfully to improve the physical standards of workmen and to make their jobs less hazardous. Employers have granted higher wages and shorter hours, introduced pension and insurance programs, and even helped their employes to purchase homes. Bankers have made it easier for workers to open accounts. Finance companies have made it possible to buy necessities and luxuries on deferred payment plans, permitting the purchasers to enjoy their purchases while paying for them.

In offering these broader opportunities to industrial workers, these various agencies have been governed purely by the instincts of good business and not by any sentimental attitude of sympathy. The man in the factory now is recognized as an important factor in the economic structure of the nation. His welfare, in the shop

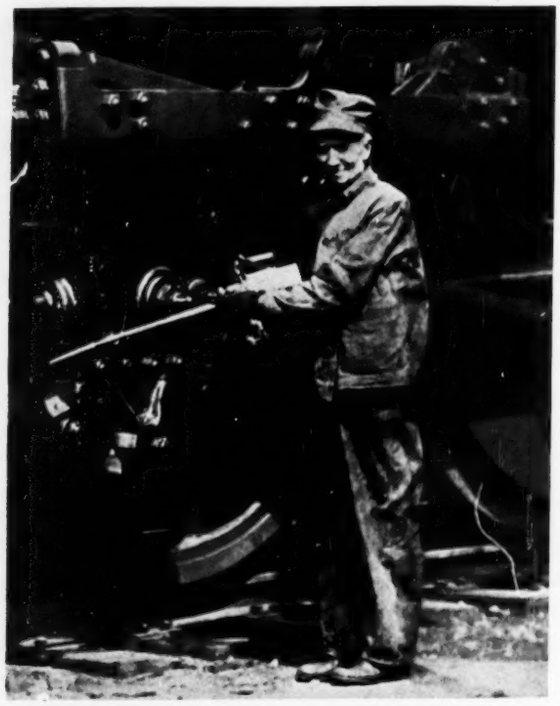
How Conception of Worker Has Changed in Five Years

A PIONEER in promoting the welfare of employes, Carnegie Steel Co. each year awards a trophy to the group which excels in safety. It is significant that whereas the 1925 *trophy, pictured at the left, shows the worker as a man of physical prowess, the* 1930 *award, at the right, presents him as an operator of a mill. Thus is recognition given to the role of machinery in industry.*



and in the home, is considered essential to national prosperity. For this reason, his needs are viewed with more concern than ever before.

If it is good business for financiers, employers, economists and management in general to advance the well being of workers, why should it not be good business for the designers of industrial machinery to do likewise?



Lubrication *Consideration of the human element by designers will hasten the exit of oil can lubrication*

Members of the engineering profession will reply that in creating machines, they already have contributed handsomely to the higher standards of living enjoyed by workmen. This is true, but it must be admitted that these benefits have come as a by-product of the profession's desire to increase the efficiency of machines, rather than from its avowed intention to assist the operators of machinery.

If we read the signs of the times correctly, we detect a growing resentment against the "machine age" and what it implies. Many critics are asking, as did John Gibson in an English periodical, "Does the scientist take the worker into account when he designs his mechanisms?" And many reply, as he replied, "Apparently not—apparently the human factor never enters his head."

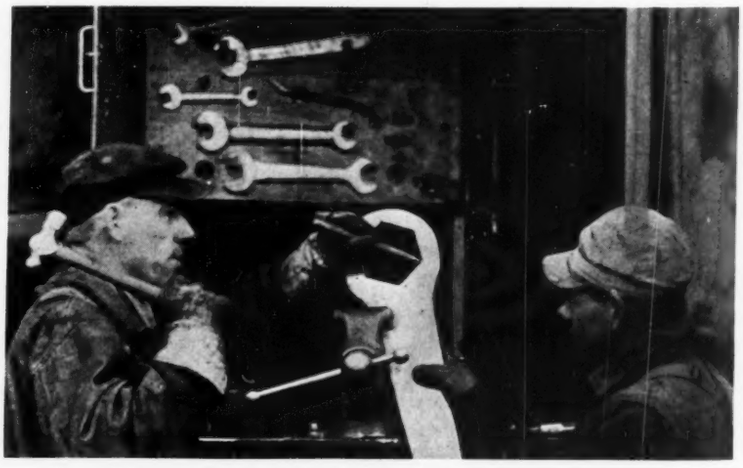
Therefore, if for no other reason than to help the critics of machinery to better understand the viewpoint of designers, would it not be good business for the profession to consider the operator's welfare when creating machines?

Let us determine what would happen if in design, more emphasis were placed on the human element and less on the factor of mechanical efficiency. At the outset, engineers would be obliged to study their machines more intelligently from the viewpoint of the operator. This would bring them into contact with problems such as convenience of operation, adjustment, lubrication and repair; elimination of avoidable noise and vibration; reduction of machine hazards; alleviation of monotonous duties, such as hand feeding; and perhaps with many other problems of similar nature.

Designers Should Study Convenience

This avenue of investigation will lead to unexpected opportunities for the improvement of machinery. Take, for example, the item of convenience in operation. Thus far little attention has been paid by the designer to the position of the operator of a machine. Of course engineers have tried to group levers, valves and other control devices so that the worker may use the machine more efficiently, but in few cases have thorough studies been made to ascertain what grouping would contribute most to the operator's comfort.

Locomotive engineers sit on a padded box, in a position that is anything but comfortable. Until recently the majority of enginemen had to throw the reverse lever by hand, and in many cases it was necessary to enlist the aid of the fireman before the heavy bar would budge. This situation assumed a stage of serious aggravation before locomotive designers eventually came to the



Simplification *Opportunity awaits engineers who will study design from the viewpoint of workers who dismantle, repair and rebuild*

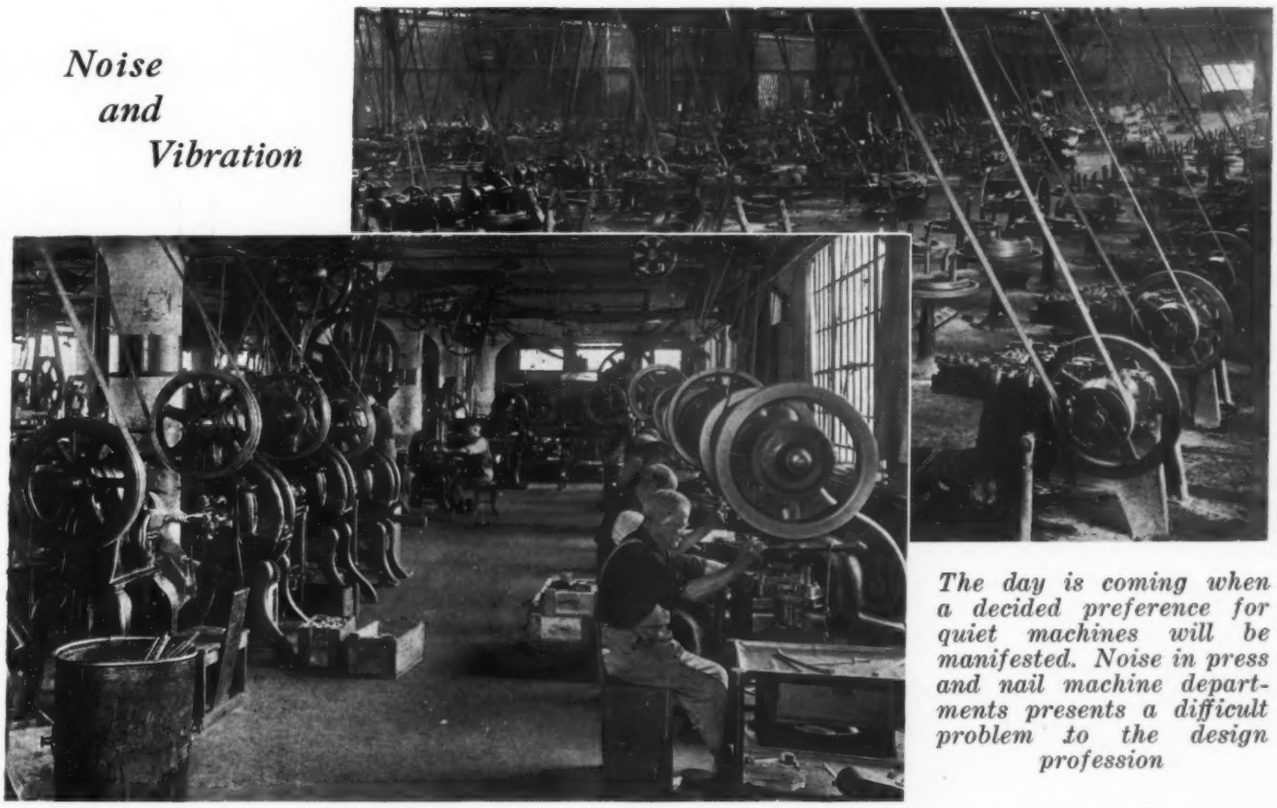
rescue with modern power operated reverse gear.

When electric locomotives came into use, the engineers were given a comfortable seat in the cab, with better vision of the track and more security from the weather. But the steam locomotive driver still exposes his right cheek to the wintry blasts while his left cheek glows from the heat of the boiler, sits in a twisted position on a square box, and reaches arm's length for his controlling valves and levers. Opportunity awaits the designer who ignoring tradition, will arrange a locomotive cab so that the engineer can enjoy comforts at least comparable to those of the motorman of a subway train, if not to those of the average automobile driver.

gation. Mill wrights, automobile mechanics and repairmen in all branches of industry are quick to spot machines that present unusual or unnecessary difficulties in dismantling and assembling. Some of the choicest profanity of the craft is uttered by machinists in the act of removing taper pins, bolts, nuts or keys from almost inaccessible recesses in carelessly designed machines. Engineers responsible for the creation of complicated machinery can well afford to spend a few hours occasionally watching workmen tearing down and rebuilding mechanical equipment.

While they agree that remarkable improvements have been made during the past few years, many purchasers of industrial machinery declare

Noise and Vibration



The day is coming when a decided preference for quiet machines will be manifested. Noise in press and nail machine departments presents a difficult problem to the design profession

Another source of inconvenience is the indifference of some designers to the desirability of detailing a machine so that its adjustment or repair involves as little trouble as possible. Less than a month ago, the head of a company which buys hundreds of thousands of dollars of machinery annually complained that he had a machine in his plant which required 40 different wrenches for adjustment and repair. It is certain that the designer of this machine could have reduced this number to ten or less, had he been more deeply interested in the problems of the user.

Simplification of design to facilitate adjustment and repair offers a fertile field for investi-

they still are not satisfied with the lubrication facilities provided on most of the mechanical equipment they buy.

One operating official writes: "While attending the Cleveland show last fall I noticed a number of machines on which it would take the operator half an hour to fill all the oil holes. I would hesitate to purchase machines of this type because of the loss of operating time and the feeling that their designers were ten years behind the times. . . . It is only fair that some comment should be made on the method of oiling from the other point of view. We purchased a machine that has 146 holes all lubricated from a central high pressure unit and it takes only two minutes

to oil all the bearings there are on the machine."

The foregoing opinion comes from one who obviously is judging lubrication from the standpoint of machine efficiency. We predict that before long users of machinery will place consideration of the human element on a par with efficiency in evaluating the merits of lubricating devices. This prophecy is based on the conviction that the increasing use of improved oiling systems on automobiles, trucks, household machines and farm implements will demonstrate the folly of the old oil can principle of lubrication so thoroughly that purchasers will insist on the modern devices on all equipment.

Here again is an opportunity for designers to look at the problem from the standpoint of the worker. Go into the shop and watch the oilers climb to their unsteady perches, where clinging with one hand to a shaft hanger, they reach with the other through a maze of belts to squirt a few drops of oil into a bearing. Note the inconvenience involved in oiling the average printing press, machine tool or textile machine. Observe the locomotive engineer—usually one in advanced years, as pictured on page 20—as he climbs up onto a side rod and reaches through the valve gear mechanism so that the tip of his two-foot oil can will connect with an obscure oil cup.

Sights such as these, which are commonplace throughout industry, indicate that we still bow to the tradition of the oil can to an extent that cannot be justified. Hand oiling of many types of machinery still is a hazardous occupation. It has cost thousands of human lives. If engineers will view the lubrication problem from the human side, they are certain to make progress more rapidly than if they wait for improvements to be forced by the demands of efficiency.

Thus far noise and vibration have been considered necessary evils, yet both of these elements in industry inflict great hardships on the workers. Fortunately a few members of the engineering profession are beginning to study this problem. They are forehanded in doing so, because the time is coming when the quiet machine will be preferred over the noisy one. Stamping presses, nail machines and similar equipment, by their very nature, cause noise and vibration that will be difficult to reduce. However, the problem is far from hopeless. In many other machines the remedy may be found more easily.

Monotony *Repetitive hand operations, as shown above, constitute work which could be done mechanically. Here is a chance for designers to display their ingenuity*

Edison says that automaticity in machine operation will be one of the most important developments of the early future. If this proves true, as it probably will, machine designers will be accorded new opportunities to create machinery that will do away with much of the monotony and drudgery now imposed on workers. The sight of men engaged in repetitive hand work, as illustrated on this page, should prove a strong incentive to designers to speed the day of automaticity.

The engineering profession is not open to criticism for not having attacked lubrication, noise and vibration, simplification, etc. more energetically. These are problems that have escaped attention in the drive for efficiency. They will be solved quickly when the emphasis in design is placed more directly on the human factor.

SCANNING THE FIELD FOR IDEAS

A Monthly Review of New Machinery, Metals and Parts, with Special Attention to Significant Design Features and Trends

Machines Eliminate Hand Labor in Mines —Aluminum for Crane Construction— Developing Gas-Electric Vehicles—Reducing Size of Fluid-Cooled Motors

TYPICAL of mechanization of industry is the rapid advance being made in equipping coal mines with machinery to replace hand labor or to render it more efficient. Methods of coal loading in particular are undergoing changes. The United States bureau of mines reports that in Illinois in 1928, about 13 per cent of the coal production was loaded mechanically, while it is estimated that in 1929 this figure was increased to almost 50 per cent due chiefly to the installation of pit car loaders.

In other directions also, the mechanization of mines continues. Conveyors and scrapers are coming into more general use, and a fairly recent addition is the pneumatic pick.

Another development in the industry is the growth of the stripping or open-pit method of mining. Here the coal industry has profited from ideas developed in the iron ore ranges of Minnesota. Success of electric shovels in that district has prompted an Illinois coal operator to install the largest power shovel in the world. This machine, the base of which is illustrated in Fig. 1, was built by the Marion Steam Shovel Co., Marion, O., and is equipped electrically with General Electric apparatus. It has an overflowing dipper capacity of 20 cubic yards—sufficient to fill from six to ten big trucks. Nothing short of amazing also is the fact that the shovel can place material about 85 feet from the ground or on top of a 7-story building. In Fig. 10 is shown an outline of the new shovel and a comparison with

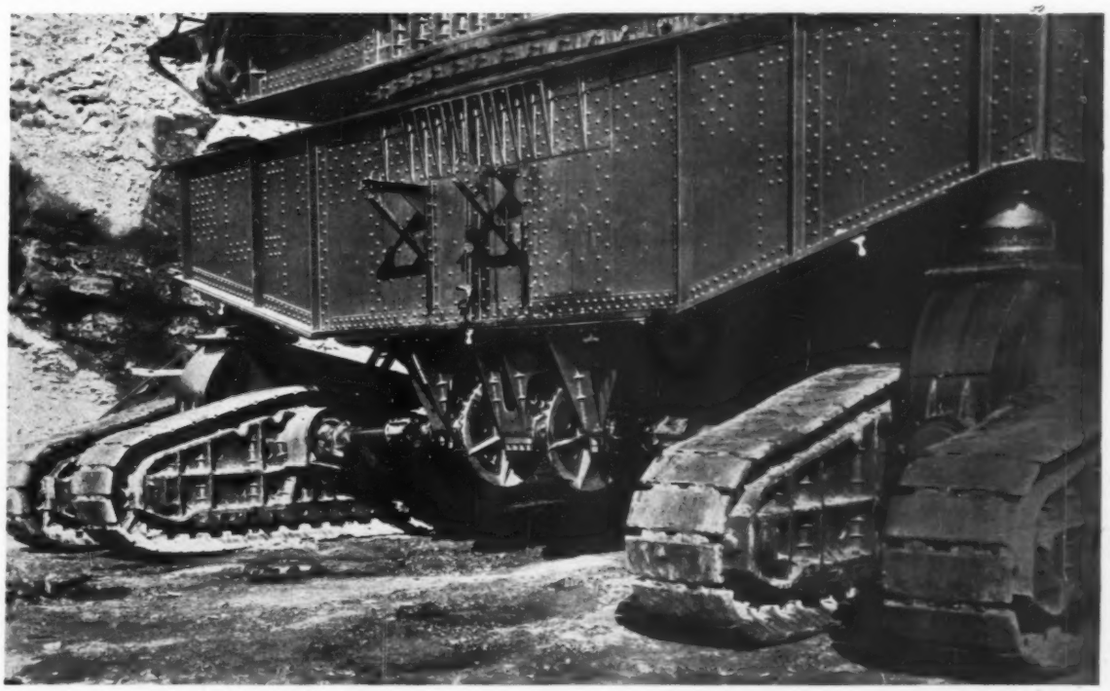
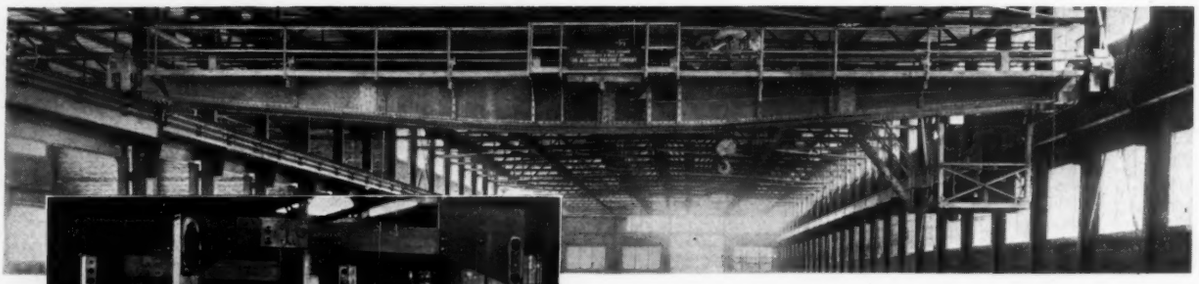
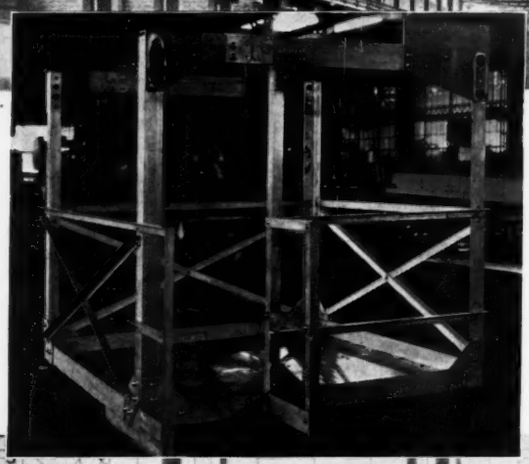


Fig. 1—Base of electric shovel which can place material on top of 7-story building

HOW MACHINE DESIGNERS ARE MEETING





WORTHY of the attention and serious consideration of designers is the aluminum alloy construction of the 10-ton crane and details shown in the accompanying illustrations. A description of the structure is given in the text on page 26, as well as a table of comparative weights of this crane and a steel one of similar capacity which had already been erected in the same plant.

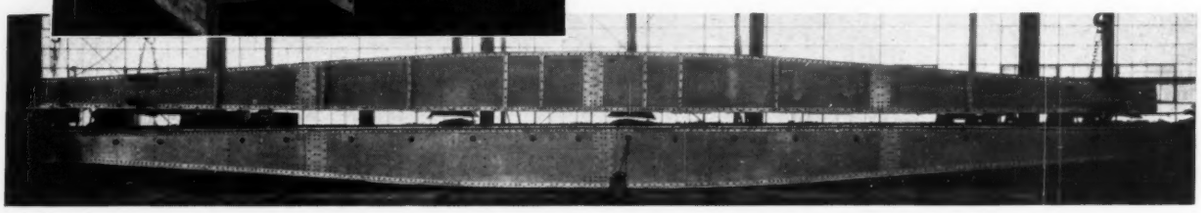


Fig. 2—Showing angles on outside of top girder. Fig. 3—(Center, Left)—Operator's cage during assembly. Fig. 4—(Top)—The completed aluminum alloy crane

AUTOMATIC flight is practically assured by the perfection of the gyroscopic mechanism shown in the accompanying illustration, built by the Sperry Gyroscope Co., Brooklyn, N. Y. It is necessary only for the pilot to take-off and land, the "mecaviator" controlling the machine continuously in straight flying.

Fig. 5—Rubber-covered wormed cutter roll as employed in the paper making industry

NO LONGER is it necessary to tack strips of material on rolls with consequent loss of product due to damage from tack heads. The composite roll shown in the above illustration is made by the Cincinnati Rubber Co., Cincinnati.

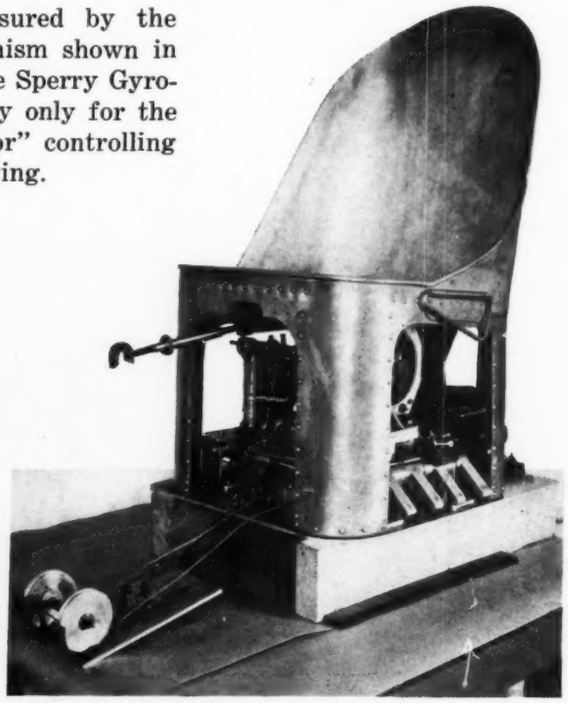


Fig. 6—Seat of gyroscope-controlled plane

THE NEW REQUIREMENTS OF INDUSTRY

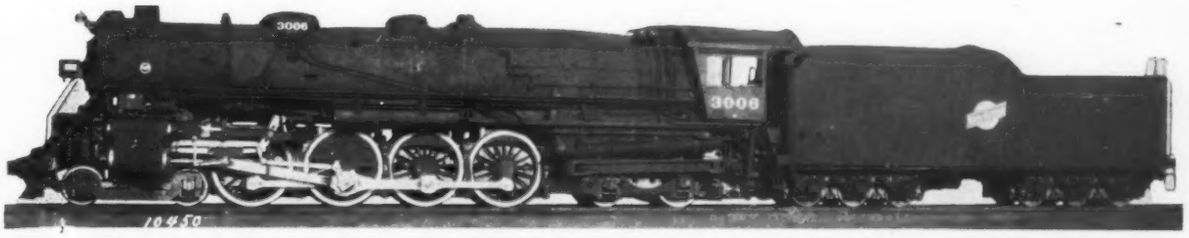


Fig. 7—Type 4-8-4 locomotive designed recently for Chicago & North Western Railway

INDICATIVE of the trend toward fabrication of more intricate castings and consequent elimination of numerous smaller parts, is the bed of locomotive shown above. This was cast in one piece and includes the main frames with all cross braces, front and back bumpers, guide, yoke supports and the cylinders. The engine was built by the Baldwin Locomotive works, Philadelphia.

THE comparison shown at the right is discussed in the text on page 26, and some advantages of the chemical coolant used are given including reduction in weight, size and frontal area.

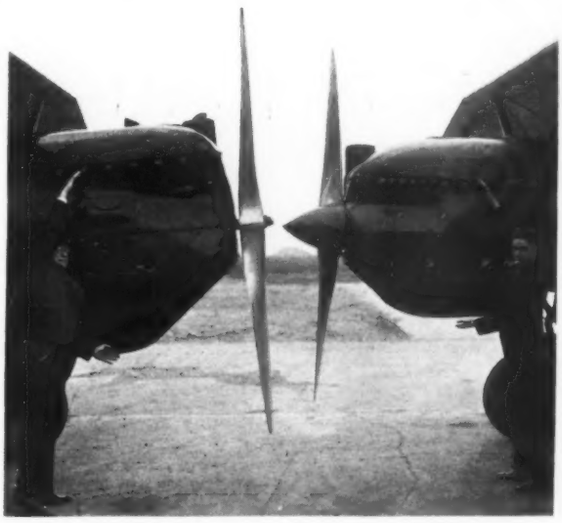


Fig. 8—Comparing sizes of engines cooled by water and chemical fluid

MACHINES as large as the one shown below usually remain in the location in which they are erected. This particular press, however, built by Dienelt & Eisenhardt, Philadelphia, is mounted on wheels and can be moved across the floor to bring it into line with one or other of several drying ovens into which the printed floor covering is fed for the drying and hardening process.

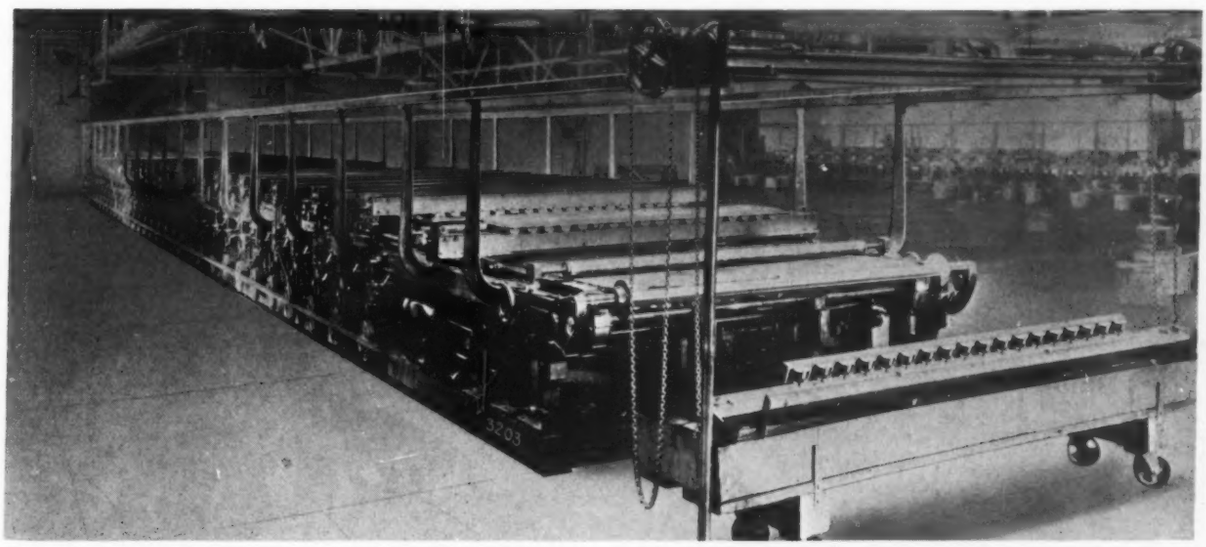


Fig. 9—This machine can print 15 colors on a floor covering in one passage of the sheet

the next largest so far built. The small silhouette indicates the size of the average standard shovel.

Electrical equipment installed on the machine aggregates approximately 4500 horsepower, the

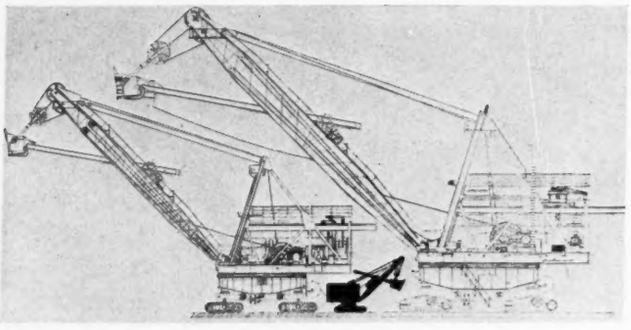


Fig. 10—Comparative size of big shovel, previous record size and standard shovel

power being taken from a trailing cable three inches in diameter. Two motors, each of 450 horsepower are used for the hoisting motion; two for the swing motion; one for the dipper trip and two small motors for the oil pumps.

It is significant to note that the design of the shovel is such that one man can control all its motions and operations.

Employs Aluminum for Girders

FAR-REACHING advance in the employment of aluminum alloys in the field of structural engineering is indicated in a report by F. V. Hartman, and E. C. Hartmann, physical testing division, Aluminum Co. of America, on the design and construction of a crane built by the Alliance Machine Co., Alliance, O., and installed in the works of the United States Aluminum Co., Massena, N. Y. The complete installation is shown in Fig. 4.

The girders, which have a span of 72 feet 2 inches, are constructed of strong aluminum alloy. Many other parts of the crane also are fabricated from this material, including the walkway, handrails and operator's cage. Figs. 2 and 3 show respectively the girders and the operator's cage during construction.

The design of the crane was based largely upon the usual practice followed in building steel cranes, although certain departures were necessary in the case of the bridge girders since aluminum and steel differ in some of their mechanical properties. While the strength of structural steel and of the heat treated strong aluminum alloys is approximately the same, the modulus of elasticity of aluminum is only about one-third that of steel. Because of this difference in the modulus of elasticity, an aluminum girder, having a cross-section identical to that of a steel girder, would deflect about three times as much under load and have less lateral stiffness. Since this is the case, it was necessary to construct the girders of the aluminum alloy crane with sections somewhat deeper, wider, and greater in area. In addition to this, the girders were given approximately twice as much camber as in the ordinary way would be used in a similar steel girder.

In the plant in which the crane was erected, a steel crane of the same capacity and span length already was in use. The two cranes being similar in design with the exception of the girders, tests have been made to compare their performance under load.

The aluminum alloy crane was found to deflect 1.8 times as far as the steel crane under the same load at the center of the span. This ratio of deflection was less than would be predicted, probably because of the stiffening effect of the extra splice material on the lighter crane. The maximum deflection measured on the aluminum alloy crane was 1.09 inches. This occurred under a load of 34,500 pounds which represents an overload of 72.5 per cent based on the rated capacity of the crane. No measurable permanent set was found in the girders upon the removal of this load. Strain gage readings taken at the center of the span indicated no stresses which exceeded those computed by ordinary designed formulas.

In the matter of performance, the aluminum alloy crane has proved satisfactory in every way. An interesting comparison of the relative weights of the two cranes may be obtained from the following table:

	Aluminum Crane (pounds)	Steel Crane (pounds)
Trolley, including motors, brakes, etc.....	16,000*	16,000
Main girder, including shafting, pedestals, walkway, etc.	14,100	24,000
Bridge motor and supports	3,900	4,800
Auxiliary girders, including conductor angles, brackets, etc.	11,900	20,200
End carriages	15,000*	15,000
Operator's cage, including controls, etc....	3,200	5,000
Miscellaneous items	2,900	6,000
Total weight of crane	67,000	91,000

NOTE: Items marked with an asterisk were not fabricated from aluminum.

Changes in Tractor Field

FOR buses having a seating capacity of 40 to 60 passengers and weighing when loaded 10 to 15 tons, and also for door-to-door delivery

trucks, a new form of drive has been developed. This is an electric drive which is not operated, as has been usual heretofore, from storage batteries but rather from a generator coupled directly to a gasoline engine of conventional design. The generator supplies one or more motors, as desired, which are mounted as shown in Fig. 11 to drive the rear axle. A gear reduction is employed between the axle and motor.

With this system, which employs electrical equipment built by the General Electric Co., Schenectady, N. Y., smooth acceleration and easy handling are obtained. The severity on the clutch of a mechanically propelled vehicle where great weight has to be set in motion, or in cases where a vehicle is stopped and started continuously also is eliminated.

It is significant that many other traction fields also have adopted a combination of gas or oil and electric drive. New York Central Railroad Co. is making use of the oil electric storage battery type of locomotive and also is planning to use the "three-power type" arranged to operate either from storage battery, oil engine, a combination of the two, or from third rails or overhead trolleys when in electric zones.

These locomotives may not have been designed to provide some form of reserve source of power, yet this undoubtedly is a great advantage, as brought out forcibly in the recent loan by the United States government of the U. S. S. LEXINGTON to the city of Tacoma. This was for the purpose of furnishing essential light and power to the city to overcome dislocation caused by failure of the hydro-electric plants to continue operation in conditions of unforeseen drought or other emergencies.

Chemical Coolant Replaces Water

WHILE the development of radial air cooled engines for aircraft has made tremendous progress in the past few years, a significant advance also has taken place recently in the water cooled engine field. This is in the use of a chemical cooling fluid in place of water, which makes possible a three-fourths reduction in the size of the radiator with proportionate reduction in head resistance. An appreciable saving in weight also is effected. The chemical fluid used is ethylene glycol, sold under the trade name of Prestone, which has a boiling point of 380 degrees Fahr. and a low freezing point. The illustration shown in Fig. 3 indicates the marked difference in radiator size and frontal area between two Curtiss Falcon planes each equipped with Curtiss Conqueror engines, one using water cooling and the other Prestone cooling. Does this mean that the radial air cooled engine is beginning to attain the limits of its possibilites of development, and

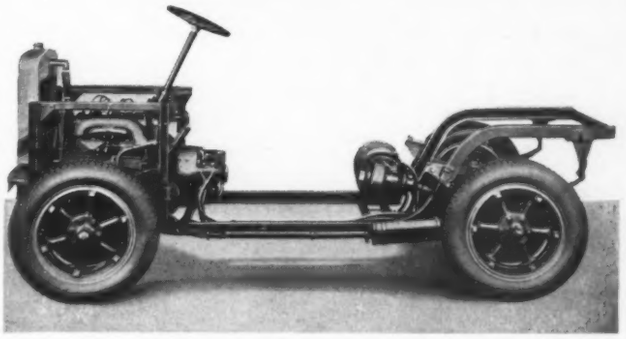


Fig. 11—Chassis of new gas-electric truck showing mounting of generator and electric motor

that renewed interest therefore is centering about the fluid cooled engine?

Diesel Engine Recognized

ANOTHER engine which has received considerable impetus of late, particularly in the aircraft field and also in machinery for road construction, is the diesel. Excessive weight always has been regarded as the handicap of a diesel aircraft engine, since cylinder pressures may approach 12,000 pounds per square inch, yet the new Packard diesel has shown that even this is not a serious handicap to light engine construction. The weight of this engine is less than 3 pounds per horsepower.

Advantages claimed for the aircraft diesel over the ordinary gasoline engine include: (a) greater reliability due to the elimination of the electric ignition system and the use of separate fuel injection applied to each cylinder; (b) decreased fire hazard; (c) engine operation is not affected by temperature and humidity conditions; (d) reduction in radio interference due to absence of electric ignition system; (e) fuel consumption reduced about 20 per cent and fuel cost about 70 per cent; (f) open exhaust ports, making possible the elimination of the weight and drag of exhaust manifolds.

Towboat With Three-foot Draft

CATERPILLAR towboats without propellors or paddle wheels are being put into operation on shallow rivers and streams by the Unit Navigation Co., St. Louis. The boats are equipped with a caterpillar drive on each side, the caterpillars consisting of chains with blades attached at intervals. Suggestion of the idea for this new type of water propulsion undoubtedly came as a result of the use of tanks in the World war.

Valve Mechanism Is Radical Feature in Cadillac V-16

By Austin M. Wolf
Automotive Consulting Engineer, Newark, N. J.

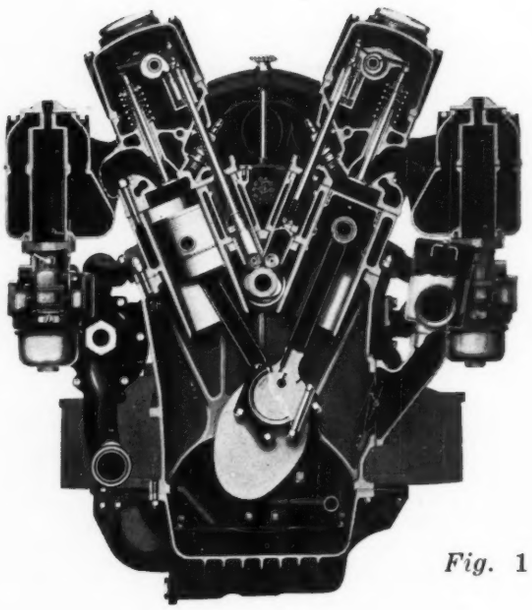


Fig. 1

WITHOUT doubt the car that stood out preeminently at the recent automobile shows was the new Cadillac equipped with a V-type engine having two banks of eight cylinders each, the included angle between them being 45 degrees. This results in eight equally spaced power impulses per revolution and also affords compactness in width far in excess of previous V-engine designs in which angles of 60 degrees and 90 degrees have been used.

Not only is this engine among the most startling of recent automobile developments, but it incorporates numerous features around which centers the interest of the machine design profession in general. The most radical and interesting advance in design is the method employed for adjusting valve stem clearances automatically, and this will be discussed in full following a brief review of some of the other engine details.

Referring to Fig. 1, it will be noted that the engine is of the valve-in-head design. The bore is 3 inches and the stroke 4 inches, giving a displacement of 452 cubic inches. It develops 180 horsepower at 3200 revolutions per minute, or the equivalent of one horsepower for every 2½ cubic inches. This is an exceptionally efficient performance for an automobile power-plant. A compression ratio of 5.5-1 is used.

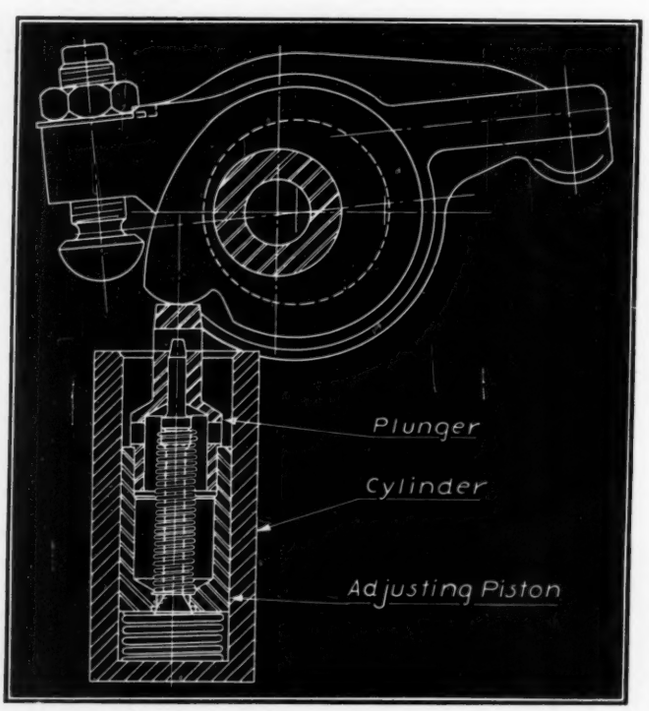


Fig. 2—*Automatic valve clearance adjusting mechanism*

Cylinder Blocks Are Staggered

The connecting rod big-ends bear, in side by side relationship, on a 2½-inch crankpin. Therefore the cylinder blocks are slightly staggered. The five crankshaft main bearings are 2⅝-inch in diameter. Four counterweights are used and also a vibration dampener the resilient elements of which consist of four pairs of small leaf springs in the flywheel member, with a pin on

the driving member extending between each pair of springs.

To combat the possibility of spring surge, two concentric valve springs of decidedly different periods are used on each valve; the valves being 15/16-inches in diameter and having an 11/32-inch lift. Springs and a valve are shown in Fig. 4.

Clearance Is Continuously Maintained

In the automatic valve clearance adjusting mechanism, a clearance is maintained at all times not exceeding the oil film thickness at the stem and at the ball joint at the upper end of the push-rod. Other than these oil films there is no clearance, and exceptional quietness of operation results. Overhead valve engines have been more or less noisy in the past and the engineers had to combat this condition which could not be tolerated in a luxury vehicle. Due to dissimilar rates of expansion in the block and the push rods, varying clearances would exist as between a hot or cold engine.

Various expedients have been used which, while partly overcoming the problem, never provided the complete solution. Duralumin push-rods once were used, to utilize their greater expansion over the cylinder block material. Push-rod compartments are kept more or less warm by controlling their ventilation with the crankcase by means of the design, and in that way control the temperature of the push-rods. Another method is to mount the rocker arms and their shafts in a separate unit or case and support this partly on the cylinder head and partly on a shaft or stud rising from the crankcase. Varying temperatures tilt the case and the design can be so laid out that the resulting differential effect neutralizes the different expansions.

With this background in mind, the Cadillac method is very interesting, particularly in view of the close adjustment maintained and because it is automatic. Trouble due to improper valve adjustment is eliminated. The construction is somewhat more costly than previous methods, but the added cost can be afforded in view of the price class in which we find this vehicle. While this first application is found in a valve-in-head engine, it also could be incorporated in side-valve engines using rocker arm valve lifters.

Referring to Figs. 2 and 4, as well as Fig. 1, it will be seen that the rocker arm is supported indirectly on the rocker shaft through the intermediary of an eccentric. Beyond the rocker arm, the eccentric is provided with a finger against which bears a spring-pressed piston submerged in oil. Exertion of the piston causes a clockwise rotation of the eccentric, thus lowering the rocker arm until it contacts with the valve stem and push-rod, leaving only the thickness of an oil film between. The spring below the adjusting piston is very weak in comparison with the valve-spring unit and in view of the lever arms between each spring and the rocker shaft, the piston exertion cannot open the valve. In the event that the relationship of the parts is such that the valve cannot seat, the valve spring pressure will cause counterclockwise rotation of the eccentric until the oil film clearance of the stem is obtained.

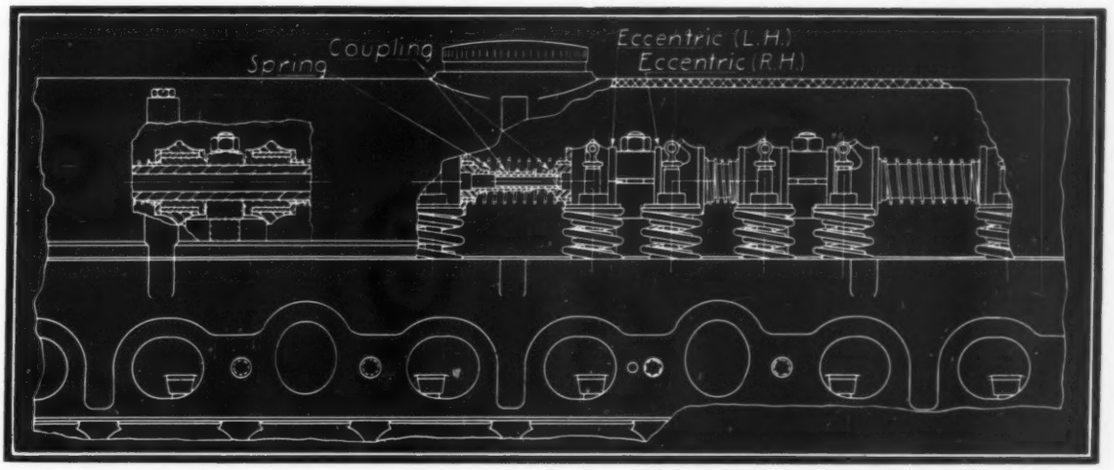


Fig. 3—Section through rocker shaft and details, showing spring-positioned rocker arms

Eccentric Held by Hydraulic Lock

During valve opening, and while the valve is open, the eccentric will not move due to the hydraulic locking effect of the adjusting piston which in reality is a dash pot that cannot be moved suddenly. A clearance of between .002-inch and .0025-inch is held between the piston and its cylinder. The piston is therefore not locked absolutely but its amplitude of motion would not exceed about .001-inch, traveling down

when the valve opens and upward after it closes because of the spring below the adjusting piston.

A spring-held check valve is located within the piston, as may be seen in Fig. 2. This allows upward movement of the piston by opening due to inertia lag in the first place and secondly by the vacuum induced below the piston when it tends to rise. The space below the piston is therefore continually filled with oil. Downward movement of the piston is allowed only by leakage around the piston. It will be seen that a continuous pumping action takes place, with only minute volumes involved. Hence the automatic adjustment is scrupulously slow as well as precise.

Overflow of oil from the rocker arm drops down onto the hollow adjusting piston, flooding

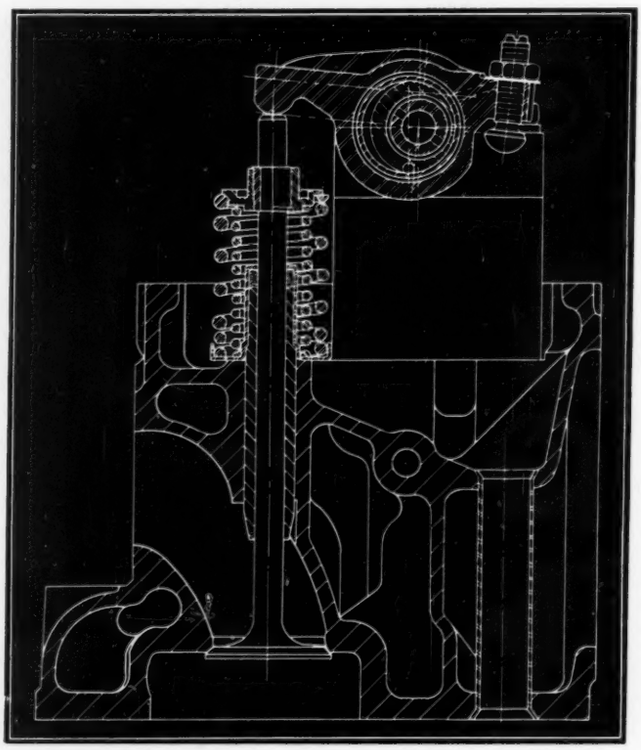


Fig. 4—Section through cylinder head

same. The rocker shafts are hollow and are fed directly from the oil filter, insuring clean oil for the adjusting mechanism. Two rocker shafts serve each block and are united by a spring-retained coupling to convey the oil flow from one to the other. Fig. 3 discloses this construction as well as the spring-positioned rocker arms.

The cylinders extend into the crankcase in barrel-fashion, bringing a high parting line between the crankcase and the cylinder blocks. By so doing it was possible to locate the camshaft between the lower ends of the cylinders and obtain the compact relationship shown in Fig. 1. By not extending the waterjackets further down, quick warming-up is possible.

Thermostatically controlled crankcase ventilation is used. Dilution of the crankcase oil and condensation of the water vapor from the products of combustion that might blow by the pistons is greatest when the engine is cold and the control allows ventilation during the warming-up process. The automatic control valve can be seen at the right side of the crankcase in Fig. 1.

To dress up the appearance of the engine, acorn nuts are used on the cylinder base flanges. A cover plate between the two cylinder banks encloses the high-tension wiring and spark, protecting them and also making a clean exterior. Each block is provided with its own carburetor and manifolds, these being on the outside of the engine instead of within the V as is required in 90 degree V-engines.

Quantity production of 16-cylinder engines for automobiles never will be reached. Its use in a luxury type vehicle where maximum smoothness of operation and accelerating ability are demanded give it a rightful place in this limited and exacting field. The departures from stereotyped construction are an inspiration to those who feel that the designers' engineering brains have not entirely succumbed to quantity production.

Designs Machine for Casting Billets Centrifugally

A machine to cast steel billets centrifugally has been designed by Leon Cammen, consulting engineer of New York, and was demonstrated recently at plant B of the Central Alloy Steel Corp., Canton, O. The unit which casts eight bars 78 inches long, 18 inches wide and from ½ to 4 inches thick at one time includes a driving medium, pouring trough and a cylindrical mold partially fluted on the interior.

The mold proper is a cast iron liner, 8 inches thick and fits loosely in a forged steel sleeve 4 inches thick, which revolves on four small wheels. Eight pleats, each resembling a capital Y are cast in the periphery of the liner and serve to relieve the excessive stresses which arise as a result of expansion during the pouring operation.

Orders received by General Electric Co., Schenectady, N. Y., in 1929 increased 28 per cent over 1928, according to an announcement by Gerard Swope, president of the company. In 1928 the orders received amounted to $348,848,512, and in 1929, $445,802,519.

Timely Re-statement of Fundamental Mechanical Principles

By Prof. John V. Martenis, M. E.
Chief Machine Design Division,
University of Minnesota

General Principles of Toothed Gearing

TOOTHED gearing occupies so large a place in the field of machine practice that a brief review of the subject will serve an especially useful purpose for those engaged in design.

Gear terminology as at present used is generally accepted as standard and is shown in Fig. 1. The term diametral pitch, or gear number, is a convenient way of relating the number of gear teeth to the pitch diameter, or $P_d = N \div D$, in which P_d is the diametral pitch; N the number of teeth; D the pitch diameter.

The reciprocal of diametral pitch, or $1 \div P_d$, is the module. Diametral pitch is an indicative number and not a linear dimension, whereas the module is expressed in inches.

The geometric forms of surfaces (called pitch surfaces) upon which gear teeth are formed may be classed as plane, cylinder, cone, hyperboloid and ellipse, producing the rack, spur, screw, helical (spiral), bevel, skew and elliptic gears as shown in Fig. 2.

Marked advances in gear practice during the past few years have brought into the field of design new applications as well as new forms of gears. The advent of gear generating machines has restricted the use of cast gears to those machines in which cost is the dominating factor.

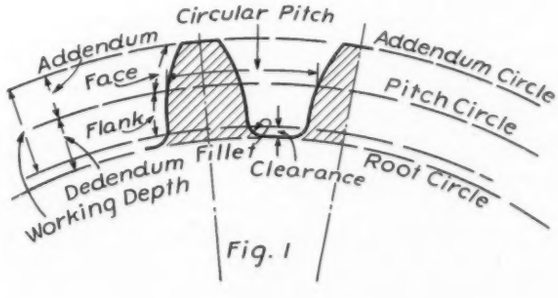


Fig. 1

The introduction of better materials for the construction of gears has made possible the use of finer pitches for a given load, and a consequent

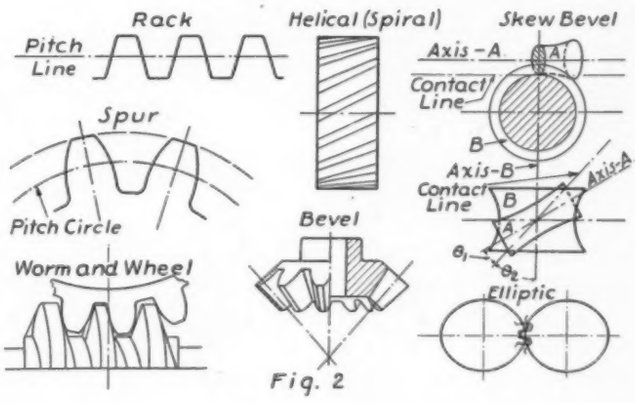


Fig. 2

increase in the number of simultaneous tooth contacts. This has the effect of promoting smoother running and a much more uniform stress distribution on the teeth.

Action of Gearing

Any sort of curve may be used to form the outline of a gear tooth but the curve conjugate to it may be undesirable. Therefore present practice has eliminated from serious consideration all but two forms of curves, namely the involute and the cycloidal, and of these the involute is practically supreme in this country. The characteristic difference in form and a simple method for drawing the involute and the cycloidal forms of curves is shown in Figs. 3 and 4.

Successive points of contact between the acting surfaces of meshing teeth form the path of contact. This may be a straight line as in involute gearing or a curve as in cycloidal gearing. In

general, the path of contact will lie between the points of intersection of the addenda circles and the tooth generating line.

The fundamental law of gearing states, "The normal drawn at the point of contact between

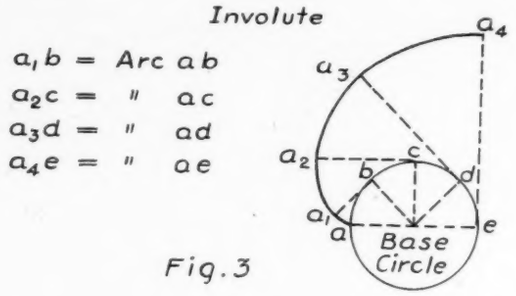


Fig. 3

two gear teeth must pass through the pitch point of the gears." This law holds for all systems of gearing where a constant angular velocity ratio is to be obtained.

In either the involute or the cycloidal systems of gearing the acting surface of the gear tooth is a rolled curve traced by a point on a generating line, called the generatrix, rolling without slippage on another line called the directrix.

The involute curve is formed by a right line generatrix rolling upon a circle as a directrix. The cycloidal curve is formed by a circular generatrix rolling upon a circular directrix.

The acting surface of the involute gear is an involute curve, and in the cycloidal gear the acting surface consists of two curves, the face being an epicycloid and the flank a hypocycloid.

In Fig. 4 the upper rolling circle generates the face of gear *B* and the flank of gear *A*. The lower rolling circle generates the face of gear *A* and the flank of gear *B*. The acting parts of the meshing teeth are generated by the same rolling circle, that is, the face of gear *A* meshes with the flank of gear *B*. To find point *t* in epicycloid, or

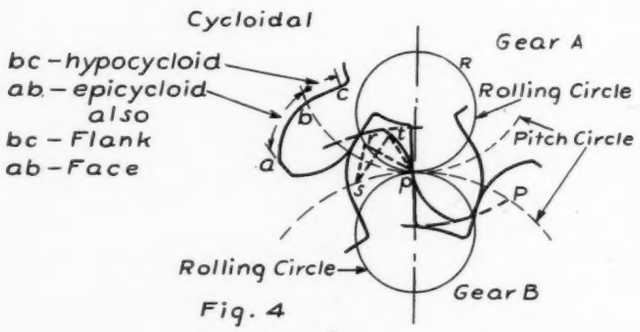


Fig. 4

face, of gear *B*, arc *pr* being equal to *ps*. With *p* as center, describe arc through *t* making *pt* equal to *rs;* with *s* as center, describe arc through *t* making *st* equal to *pr;* then *p* moves to *t* as *r* rolls to *s*.

In all systems of gearing, the point generating the tooth form for one gear also must generate the corresponding tooth form on the meshing gear and from this condition it is evident that the normal through each point of contact between these curves must lie on the generating line which passes through the pitch point of the gears. This necessary condition can be shown in another way. Fig. 5 shows two tooth curves in contact at point *d* and the normal *n n* common to the two curves at point *d*.

The centers of gears *A* and *B* are O_1 and O_2 from which points are drawn O_1 *a* and O_2 *b* both perpendicular to *n n*. In circular motion the linear velocity of a point equals its angular velocity times its radius, and in the given case, the linear velocity of *a* equals the angular velocity of O_1 times O_1 *a*. Similarly, the linear velocity of *b* equals the angular velocity of O_2 times O_2 *b*. Since the linear velocity of *a* equals that of *b* along the line *n n*, it follows that

$$\frac{\text{Angular velocity } O_1}{\text{Angular velocity } O_2} = \frac{O_2b}{O_1c} = \frac{O_2c}{O_1c}$$

from similar triangles.

If the normal at any other point of contact should pass through some point other than *c*, the ratio would be different and the gears would not have a constant angular velocity ratio.

Pressure Line Has Fixed Relation

In the involute system of gearing the pressure line or generatrix of the tooth curves has a fixed relationship to the pitch circles of the meshing gears when the pressure angle is known and this line also contains all points of contact between the acting tooth curves. Therefore the path of contact extends from *e* to *f* and evidently this line passes through the pitch point *c* of the gears *A* and *B*. In the cycloidal system of gearing the tooth curves are traced by a point lying on a circle generatrix *D*, called the rolling circle, which must generate those portions of the meshing gear teeth which are to work together; therefore the point *d* on the rolling circle *D* will generate the flank of the tooth on *A* and the face of the tooth on gear *B*. The path of contact between meshing teeth in the cycloidal system of gearing will lie on the rolling circles and in this case will extend from *g* to *h*.

The relative motion of the links of a mechanism can be taken about some point acting as a center. This point, for directly connected links, will lie in the connector and for links not directly connected will lie at a point so related to the links that it will have the same motion whether it be considered as a part of either. In rolling contact the only point so related lies at the contact

point, therefore in the present case the center, called instant center, of the motion of d (a point common to both gears) will be at c, and $c\ d$ will contain the normal drawn at the point d.

Relative Tooth Motion

The contact point d in Fig. 6 is common to each of the meshing teeth and has a direction of motion along the line $d\ m$ as it moves about O_1 as a center, and along the line $d\ n$ as it moves about O_2 as a center. The motion of d along the common normal $a\ d$ will be the same whether it is considered a point on tooth A or a point on tooth B. Let $d\ p$ represent the motion of d along the common normal, then $m\ p$ is the sliding component of d as a point on tooth A and $n\ p$ is the sliding component of d as a point on tooth B, therefore the relative sliding action of teeth A

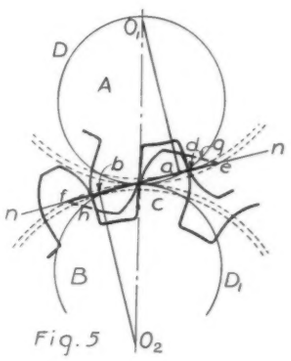


Fig. 5

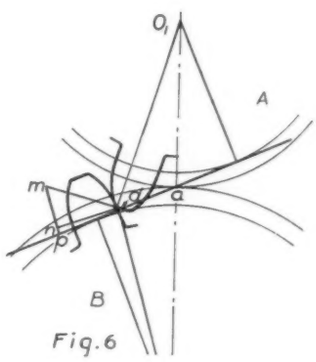


Fig. 6

and B in the given position is represented by $m\ n$.

This condition can be shown for every contact point except at the pitch point of the gears a, therefore pure rolling action occurs only when the meshing teeth are in contact at the pitch point of the gears. The sliding rate increases as the contact point lies farther away from the pitch point a, hence the sliding action between the teeth of meshing gears will be determined by the amount of addendum given to the teeth.

Conjugate Tooth Curves

Conjugate curves as applied to gear practice may be defined as curves so formed that the common normal at each point of contact will pass through the pitch point of the gears, hence such curves will provide the conditions required for true gear action and conform to the fundamental law of gearing.

For any given tooth curve a conjugate curve can be drawn. For example, assume the outline of tooth A Fig. 7. It is required to find a tooth outline that will be conjugate to it. Select any point a on the given curve and draw a normal

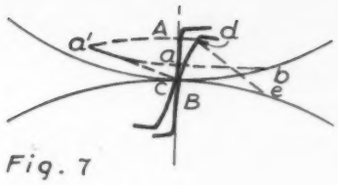


Fig. 7

$a\ b$. The point on tooth B that will be conjugate to a must be so placed that the common normal to the two points in their contact position will pass through the pitch point c of the gears. To find the conjugate point, swing the normal $a\ b$ backward about the imaginary center of gear A at O_1 until b falls at c and a is at a', in which position a' will be in contact with a point on tooth B that is conjugate to a because in this position of teeth A and B, the common normal at the point of contact passes through the pitch point of the meshing gears. To locate this point of tooth B in the given position of the gears, swing the normal $a'\ c$ about the same center O_1 back to its original position $a\ b$, and at the same time swing $a'\ c$ about an imaginary center O_2 of gear B to $d\ e$. Then d is a point on tooth B that is conjugate to point a on tooth A. Repeat this procedure for a sufficient number of points to fix the curve.

Involute Gears

Fig. 3 shows a method of drawing the involute and this curve will form the working part of the involute tooth.

From the manner in which the curve is generated, it is apparent that the base circle will limit the involute portion of the tooth, and any part of the tooth lying inside the base circle must have a form that will not cause interference with the teeth of the meshing gear. Since the face of the tooth is formed by an involute, the addendum may be extended until the tooth becomes pointed, as shown in Fig. 8. Since the size of the base circle determines the rate of curvature of the involute, the smaller base circle produces a tooth having a shorter addendum.

The magnitude of the pressure angle will determine the size of the base circle, due to the fact that the base circle is drawn tangent to the

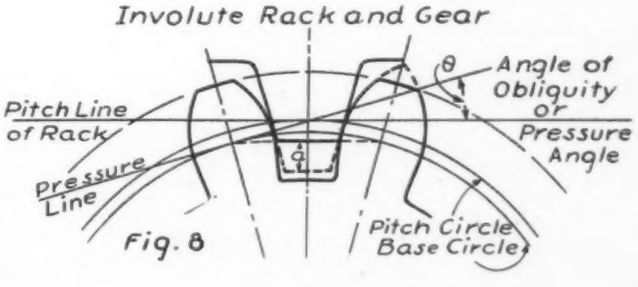


Fig. 8

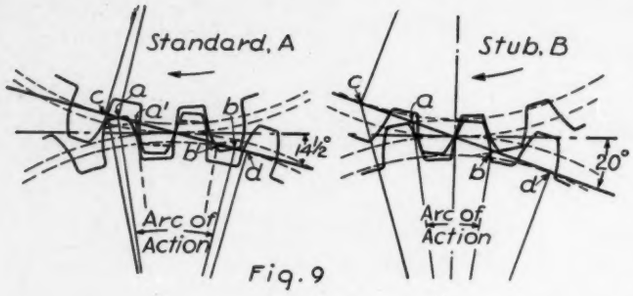


Fig. 9

pressure line. Therefore a large pressure angle will give a relatively small base circle and consequently the involute will approach nearer the center of the gear.

A pressure angle may be selected that will permit the formation of the face and flank of the tooth without resorting to the radial or other forms of flank extension (see Fig. 9-*B*).

One involute will be conjugate to another having the same pressure angle and the extent of true gear action will lie within the limits set by the points of tangency of the pressure line and the base circles of the meshing gears. This condition will determine the permissible addendum that may be used in a given case, for instance, in Fig. 10, the addendum of the teeth on gear *A* should not extend beyond the point *a* and likewise the addendum of the teeth on gear *B* should not extend beyond the point *b*, for the points *a* and *b* fix the limits of pure gear action.

In Fig. 8, the addendum of the rack tooth should not be more than shown in full line, and if the addendum extension *A* is taken, provision must be made to avoid interference.

Involute gear systems are designated in two ways, either from the pressure angle used or from the addendum used. In the first system, the pressure angles commonly used are: 14½ (standard), 20 (Fellows), 22½ (A.S.M.E.) and in the second system, the addendum may be $1 \div P_d$ (standard) or less than $1 \div P_d$ (stub). Fig. 9 shows a comparison between the action of a 14½ pressure angle and a 20 pressure angle. It is apparent in either case that the addendum determines the arc of action and in both cases the arc of action will be the same if the addendum of the 14½ tooth is shortened to the dotted line as shown. In any case the arc of action must at least equal the circular pitch and in practice is rarely taken less than 1¼ times the circular pitch.

An increase in the arc of action provides more actual pressure contacts between meshing teeth which in turn gives a more uniform distribution of the load on the teeth. This provision may be advantageous in some cases, especially so for gears made from materials of doubtful quality. Other factors being equal, the shorter arc of contact conduces toward higher efficiencies due to the nearer approach to pure rolling action in the zone adjacent to the pitch point of the gears. The larger pressure angle produces a strong form of tooth and if in addition the addendum is shortened, the working height of the tooth will be less.

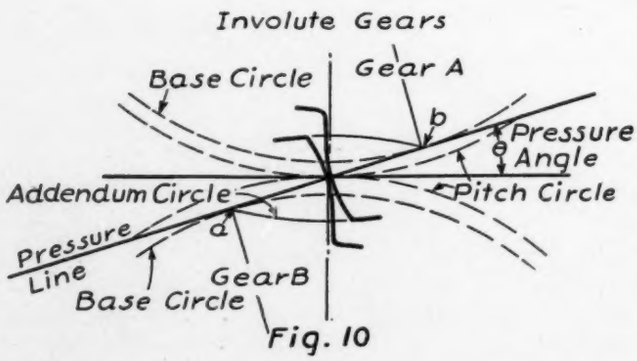


Fig. 10

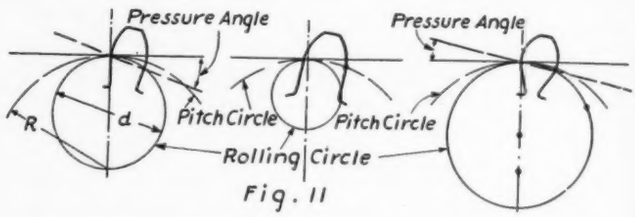


Fig. 11

Therefore a gear formed under these conditions will be capable of carrying heavier loads than a gear having a less pressure angle and a longer addendum.

Cycloidal Gears

The application of cycloidal curves for gear tooth formation antedates the use of the involute but the use of cycloidal gears has decreased rapidly during the past few years and at the present time is used rarely in machine practice in this country.

As shown in Fig. 4, the cycloidal tooth consists of two forms of the cycloidal family, namely the epicycloid and the hypocycloid, the former curve forming the face of the tooth and the latter forming the flank. The epicycloid is formed by rolling the generating circle externally on the pitch circle and the hypocycloid is formed by rolling the generating circle internally on the pitch circle. The rate of curvature of the generated curve depends upon the relative sizes of the generating (rolling) and the pitch circles. For gears having relatively large numbers of teeth, the size of the rolling circle is not so important as it is for gears of few numbers of teeth. The size of the flank rolling circle is subject to certain restrictions where the tooth strength is concerned. In Fig. 11 are shown three cases illustrative of the effect produced by varying the relative sizes

(*Concluded on Page* 38)

How Designers Can Appraise Metals from Hardness Test Data

By E. S. Ault

Assistant Professor Machine Design, Lehigh University

NUMEROUS scientific methods are in daily use for the hardness testing of materials before or after heat treatment. Each method, however, varies to a certain degree in the properties measured. It therefore is necessary that designers be conversant, for successful specification or application, with the characteristics of the best known instruments, which information is presented in the accompanying article prepared by Prof. Ault following intensive study of the subject.

QUALITY of hardness admits of no inclusive definition. Some conceive it to be the resistance to wear, or scratching with a hard tool; some view it as the resistance to penetration, and others as the resistance to crushing. The definition most generally accepted by engineers is: "Hardness is the property of resisting the local displacements of portions of its substance by contact with another body." This displacement may take place by plastic flow or by direct fracture.

Deformation under a static test depends upon stresses of unknown nature, magnitude, and distribution; hence, to measure hardness we must observe the results of these stresses and express these results in a comparable form. To do this similar stresses must be produced in a body and the consequences reduced to a single constant representing the degree of hardness of that particular material.

The different ways of measuring hardness give results that are not in accord and obviously measure different properties. A piece of cold-rolled copper wil give a higher Brinell number than mild steel, yet the steel will cut the copper whereas the copper will not cut the steel.

Indentation tests measure resistance to flow and compression as well as elasticity. The rebound test measures elasticity to a greater extent than it measures resistance to indentation. Abrasion tests measure cohesion and retention of separated particles. Even the same methods using tools of different shapes give different results, and variation of the load in the static ball tests gives

Purpose	Test Used				
	Indentation	Rebound or Impact	Scratch	Impact	Abrasion
1. For controlling carbon content in the iron and steel industry	✓	....	....	....	....
2. For controlling the proportions of the constituents in alloys	✓		....	....	....
3. Approximate measure of the tensile strength where tensile test is impossible	✓	....	....	....	....
4. Checking the uniformity of composition	✓	✓	....	....	....
5. Checking the uniformity of heat treatment	✓	✓	....	....	....
6. Holding manufactured articles within a standard	✓	✓	....	....	....
7. Determining the effect of cold-working	✓	✓	....	....	....
8. Determining the effect of temperature and composition of quenching media	✓	✓	✓	....	....
9. Determining the effect of heat treatment	✓	✓	✓	....	....
10. Research—properties of crystals, different phases of an alloy, etc.	✓	✓	✓	....	....
11. Checking case hardening	✓	✓	✓	....	....
12. Determining the properties of materials at high temperatures	....	....	....	✓	....
13. Indication of resistance to wear	....	....	....	....	✓

a corresponding variation in the hardness number obtained, on account of the dissimilar geometric shape of the impression, different friction between the material and the tool, and cold-working of the material. A further difficulty in comparing methods, not chargeable to the methods themselves, is the variation in hardness throughout a piece of material carefully heat-treated.

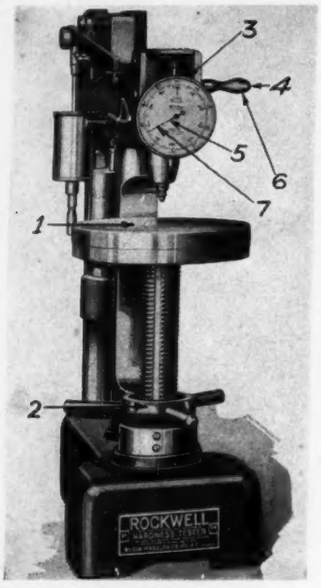


Fig. 1 — Rockwell hardness tester

(1) *Testing table or anvil*
(2) *Wheel for applying minor load*
(3) *Bezel to set dial zero*
(4) *Handle for applying major load*
(5) *Moving pointer*
(6) *Forward pull releases major load*
(7) *Pointer gives direct reading*

Hardness, as found by the static indentation test, is expressed generally in kilograms per square millimeter of area of indentation, of either the spherical surface as used by Brinell or the projected area as used by Meyer. The latter seems more reasonable. The measure also may be taken as the load necessary to displace a unit volume or to give a certain depth of penetration, which method seems to be the most satisfactory.

Penetration Determines Hardness

The Rockwell uses an arbitrary scale based on depth of penetration. The hardness number for dynamic indentation is the ratio of the energy of the falling hammer to the volume of the indentation, or some relation of diameter of indent to energy. The rebound test uses an arbitrary scale to measure the height of rebound; the scratch test uses the weight necessary to produce a scratch of a certain width, or expresses the hardness as a function of the width squared or cubed. Abrasion tests use an arbitrary amount of wear as the standard.

Many opinions of hardness have been expressed and a large amount of testing done, but still the qualities of hardness have not been isolated and measured, and the discordance of the different methods causes confusion in fixing upon a standard measure. A particular quality may be secured by specifying a certain test, but to be useful hardness number must be accompanied by a statement of the conditions under which it was made; thus a Brinell number should be accompanied by the amount of load and the diameter of the ball, if not standard, and preferably by the time of application of the load. A satisfactory analysis and definition in terms of molecular physics, consistent with known phenomena, should be agreed upon.

Requisite Kind of Hardness Varies

The kind of hardness desirable under different conditions is not the same, as is readily seen when the necessary properties are considered. The material may be used (1) as a tool to cut another material, (2) to be cut by another material, (3) to resist abrasion, (4) to resist scratching, (5) to resist penetration. The requirements for these five conditions are:

(1) A cutting tool must have, primarily, a high shear strength to resist pressure at the small cutting tip. To be effective it must possess hard, sharp cutting particles imbedded firmly in a softer base material that resists their being torn out.

(2) When a ductile material is cut by a tool of a harder material the cut metal tears at the surface being finished and shears at the top of the surface being removed as the chip is deflected. A brittle material shears off at the finished surface. Resistance to cutting would accompany high shear strength and high tensile strength. High

Fig. 2—Side view of machine for Brinell ball point hardness testing. The pressure is weighed by a system of levers to beam and poise

density and toughness also increase the resistance to cutting. Hard particles in a softer matrix would not give high hardness but would cause wear of the cutting tool.

(3) Resistance to sliding abrasion and wear is the result of hard particles imbedded firmly in a matrix of high tensile strength. Certain bronzes are good examples of this formation. Resistance to the abrasion of a sand blast is greater with uniform hardness where there are no softer particles to be removed.

(4) Resistance to scratching is not the resistance of an aggregate of crystals but is determined by the shear strength of the individual crystals, which are scratched separately. Resistance to penetration increases resistance to scratching for the point must first penetrate the material before scratching can occur.

(5) When a material is subjected to an indenting force it is compressed and flows, if ductile, to a failure through shear. High compressive strength and high shear strength give resistance to penetration.

The above conclusions are reached without regard to the effect of cold-working. Manganese steel, for instance, although giving a low measure of indentation hardness, gives high resistance to cutting and wear because the slightest mechanical working disturbs its stability and causes considerable increase in hardness. Although the tungsten carbides such as "Widia" and "Carboloy" are our "hardest" alloys, manganese steel has the greatest capacity for hardening. The effect of temperature upon the properties discussed has been disregarded.

Uses of Knowledge of Hardness

The knowledge of the degree of hardness is useful in determining and checking the composition, properties, and utility of a material. It is used generally in conjunction with the knowledge of other properties and is, of itself, only a partial indication of the properties and history of the piece. The Brinell hardness number of a piece of cold-worked steel gives, in addition to the degree of its resistance to penetration, an approximate knowledge of its tensile strength, its further capacity for cold-working, and an indication of its heat treatment if its composition is known. All of the tests for hardness are possible for most purposes but some particular conditions necessitate a certain test.

Some of the uses of the knowledge of hardness and the tests employed to determine it are as indicated in the table on page 35.

Any endeavor to obtain a direct relationship between the hardness as measured by the different methods is bound to fail, for each method is dependent upon factors other than the one that could be called "hardness" alone. The scratch test gives a measure of shear strength and density; the rebound test gives a measure of resilience which is some function of the elastic limit; the indentation test gives a measure of the resistance to compression that is almost hydrostatic and may be proportional to tensile strength.

A general relation between Brinell and Scleroscope readings has led to numerous attempts to obtain a conversion table or factor. Endeavors to relate the two have not been very successful and tests on a range of materials by Thomas and on a thousand tests on open hearth rail steel by Cushing showed considerable variation. Cushing's steels gave a ratio of Brinell to Scleroscope readings varying from 4.97 to 14.11 with an average value of 7.56. Four thousand tests upon 300 types of plain carbon and alloy steels were made by Abbott and plotted in groups according to composition. He computed a straight line by the method of least squares to represent each group but the points are widely scattered.

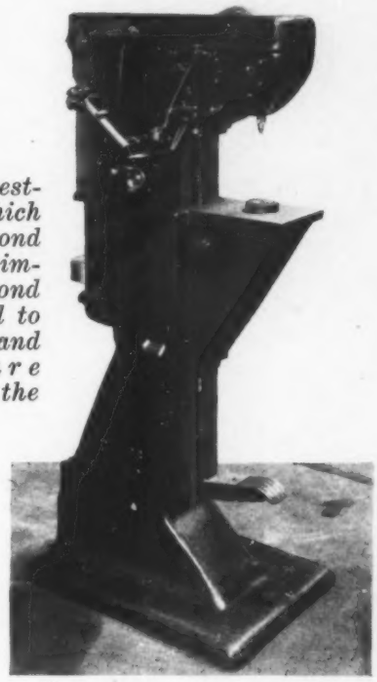


Fig. 3—Vickers testing machine which employs a diamond for obtaining the impression. The diamond is cut and polished to form a pyramid, and measurements are taken across the corners

Other tests which have been made indicate practically the same results. The ratio Brinell to Scleroscope varies for different materials, and even for the same material, and changes according to the ball diameter and the load. Although this ratio usually is taken as 6, it is but roughly approximate and may give an error as high as 30 per cent. The greatest variation is where toughness exists. For closest conversion a factor

should be obtained for each material from approximately the same composition and hardness with the particular instrument under standard conditions of testing.

Rockwell and Brinell Are Similar

The Rockwell test gives a fairly close relation to Brinell but differs somewhat because of size of ball and amount of load. Furthermore the Rockwell measures a more local hardness and the Brinell gives an average over a larger area.

The Vickers test, using a diamond ground to a square-based pyramid, gives corrected Brinell numbers independent of the load because the impressions are geometrically similar.

Herbert's pendulum time test is essentially a ball indentation test and is convertible into Brinell numbers, but the results of the scratch test show no relationship to the other methods.

A comparison of hardness, as measured by the tests, with other physical properties cannot be made satisfactorily because of two reasons, (1) errors in obtaining the hardness number, and (2) lack of homogeneity of the material. However, within these errors some general relations are observable.

The popularity of the Brinell test is largely the result of its close relation to the tensile strength. This relation was first pointed out by Brinell and confirmed by many others. For ferrous metals the tensile strength may be obtained within 10 to 20 per cent by multiplying the Brinell number by an approximate average coefficient of 500. This relation does not hold for nonferrous metals. That the Sclerescope gives no regular relation to the tensile strength has been shown by many investigators; in fact, it does not claim to do so. It does give a general indication of the elastic limit for some materials.

There is no definite relation between measured hardness and resistance to wear and abrasion, although a high Brinell number may be expected to wear well.

Cold Working Increases Toughness

No relationship is apparent between the efficiency of a cutting tool and Scleroscope or Brinell, as the cutting ability is dependent upon the hard particles, and hard particles do not cause the whole body to be physically hard. Hardness and toughness may be increased by cold work, but the cutting ability is dependent upon the hardness of crystals produced by thermal treatment. The same applies to resistance to cutting; a cold-worked piece may be cut by a piece thermally treated to a lesser hardness. Experiments have failed to disclose a relationship.

Hardness is a term applicable to different properties and as defined at present cannot be measured alone. Any isolation and measurement of hardness is improbable, and as the qualities required for different purposes are also dependent upon shear strength, tensile strength, toughness, and other properties, a direct measure of materials for particular uses must be a test under the condition of these uses. When the proper material has been so selected, its production may be controlled by composition and treatment and checked by hardness test. There is little positive relation between the various tests for hardness and except for the approximate relation between Brinell and tensile strength there is little connection between the measured hardness and the other physical properties.

Fundamental Mechanical Principles

(*Concluded from Page* 34)

of rolling and pitch circles. It will be noticed that the hypocycloid becomes a radial line when the rolling circle diameter equals the pitch circle radius thus giving rise to the radial flank, which condition is basic for the determination of the rolling circle diameter. There are two systems of cycloidal gearing, one in which the rolling circle will generate a radial flank for a 12 tooth pinion and the second in which the rolling circle will generate a radial flank for a 15 tooth pinion. The first or 12 tooth base uses a smaller rolling circle than the 15 tooth base in the ratio of 4 to 5.

Pressure Angle Is Reduced

For example, assume a 3-pitch gear, for which the 12 tooth base will use a rolling circle having a diameter equal to the radius of a 12 tooth pinion, or $12 \div 3 = 4''$; therefore the rolling circle is 2″ diameter whereas in the 15 tooth base the rolling circle is $2\frac{1}{2}''$ diameter ($\frac{1}{2}$ of $15 \div 3$). The 15 tooth base produces better gear action because the average pressure angle is less, as may be seen from Fig. 11. In cycloidal gears the path of contact lies on the arcs of the rolling circles between the points of intersection of the addendum and rolling circles (see Fig. 4) and the pressure angle is changing constantly from a maximum at the first point of contact to zero at the pitch point in approaching action, and from zero at the pitch point to a maximum at the final point of contact in receding action. From the foregoing it is apparent that the quality of gear action in the cycloidal system can be controlled by selection of rolling circle and addendum.

Part VI

Blueprint and Record Section—Filing of Drawings—Blueprinting—Reproduction Machines—Costs—Conclusion of Series

WORK of an engineering department only begins to bear fruit when the designs originated therein actually are made and fabricated in the shop or field, are delivered and installed, and operated by the purchaser. Drawings or tracings, while they may appear to be the real product of the designer and draftsman, have no conclusive utility in themselves, unless it occasionally is to demonstrate the futility of some embryonic idea. While actual production is not under the direction of the engineering department executives, there is one other step in the long path to ultimate achievement that decidedly is. This step involves the work embodied in the significant part of a design department responsible for the delivery of its products in usable form in the shops—the blueprint and record section.

The work of this section, particularly in a large organization, requires a great deal of painstaking, systematic routine, which must be handled with a flexibility responsive intelligently to emergencies. It is work which by its character is foreign and distasteful to the true creative mind of the designer, which instinctively loses interest in a problem once it has been solved technically. Therefore, good management aims to so organize its resources, that all work outside of the actual production of drawings shall be delegated away from the more expensive designer and draftsman, and co-ordinated into the activities of one section.

CONSIDERABLE importance attaches to the routine work which must of necessity be carried on in engineering departments, particularly in the record and blueprint section. For this reason the accompanying article—the last of Mr. Hardecker's series—will be read with much interest. The number of commendatory letters received, as each installment in the series has appeared, points conclusively to the value obtained from this series.

Maintenance of Records Essential

This section should reproduce and distribute the work of the department as required, in the form of blueprints, vandykes and photostats, and maintain files of tracings, blueprints and vandykes. It should maintain records on all local and foreign drawings, numerically, alphabetically and in terms of projects, noting dates of issue and re-issue, obtain receipts for all dis-

tribution and file all change notices. It serves as an engineering information bureau for the entire organization.

Probably the work can be traced best by a consideration of the functional duties of the indivduals who comprise it. In a small organization, certain of these duties may be combined under one individual, while in a large organization many of the functional assignments would require assistants.

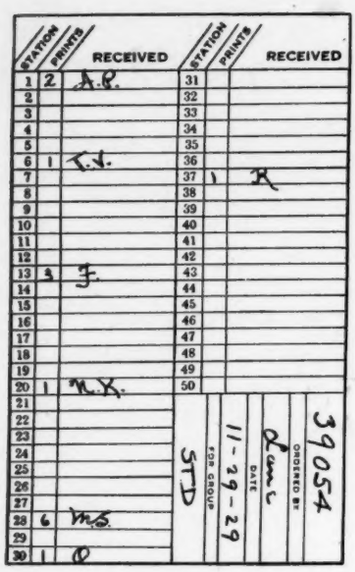


Fig. 1—Blueprint order form which is prepared and time-stamped as tracings are submitted for issue. The form acts also as a receipt

The supervisor of the blueprint and record section, in addition to the obvious duties of supervision, should have certain specific functions. The supervisor should initiate and handle all correspondence with respect to the forwarding and receipt of prints, initiate purchase requests and receipts for all drafting room material, printing material and stationery, and act as routine assistant to the chief draftsman. In addition, the supervisor of this section should review and approve all drawing titles prior to their use, in order to maintain uniformity of nomenclature.

Clerk Issues Drawing Numbers

The record clerk should furnish drawings numbers upon request for properly approved titles and prepare all numerical, alphabetical and model index cards. An alphabetical index is best kept on library cards filed in drawer cabinets, so that entire groups may be removed freely for inspection by information seekers. The same procedure is true for cards grouped by models. The numerical cards, which are the active record cards giving title, drawing number, draftsman, issue and re-issue dates, cancellations, superseding information, etc., are best kept in some type of visible index file, so that they are accessible for quick reference by the section personnel.

The issue clerk prepares all local and foreign plans for issue and distribution, checking all drawings for information and sufficient authority for issue, and noting issue and re-issue dates on numerical record cards. This clerk should be responsible for the proper routing of issues, which information should be established for specific models by some form of standardized routing. For miscellaneous issues, a generally established routing should be used unless specific orders are given to the contrary. This clerk also may handle the numbering and checking for issue of project engineers' slips, bills of material, assembly sheets, etc., where such are a part of the current system. In such cases, the clerk also should check that all referenced information has been issued previously or is available for issue before releasing these items. Where deemed essential in a large organization, this clerk also may keep a daily loose leaf record of the issues each day.

Information Readily Accessible

The information clerk should furnish all drawing information to those consulting the record section. This involves drawing numbers, status of drawings, model numbers and all information appearing on the various record cards. In addition, this clerk may prepare miscellaneous summaries, special lists, check various lists regarding status of drawings as to obsolescence, etc., and perform the miscellaneous duties of the section.

The order clerk should prepare the print order

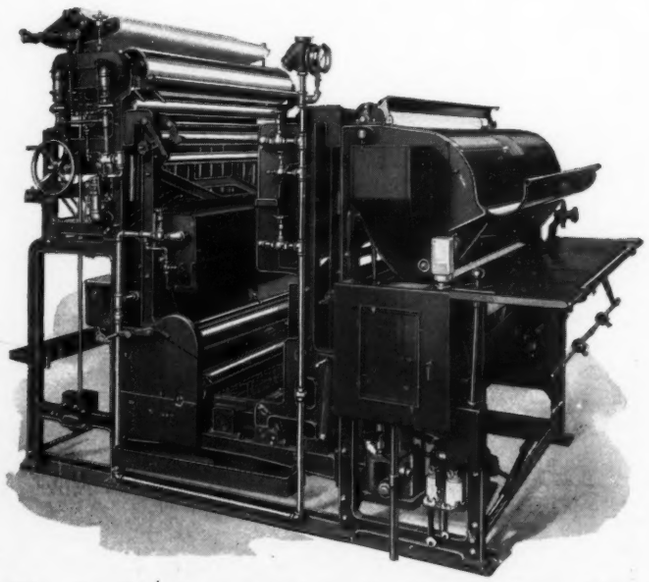


Fig. 2—Continuous automatic blueprint machine

form shown in Fig. 1, as tracings are sumbitted for issue, time-stamping the form as prepared. This form acts also as a receipt, the various stations about the factory initialing opposite

their station number upon the receipt of prints. All originals are filed by this clerk—tracings, vandykes, project engineers' slips, change slips, reports, etc., and he is responsible for the upkeep and accuracy of the plan files. Obsolete plans should never be destroyed, but should be filed in suitable equipment in a vault to which obsolescent tracings may be transferred from time to time.

The blueprint clerk is responsible for the accuracy, neatness and upkeep of the blueprint files. These files should be maintained for the reference and loan use of the entire organization as well as the engineering department. Great care must be exercised to see that only current issues of prints are kept in the active file. Careful record should be kept of all borrowers, so that loan prints may be located readily, and systematic check-ups for return of prints initiated.

Flexibility in Personnel Is Desirable

Successful functioning of the record section personnel demands that extreme flexibility be maintained at all times. Each individual should be acquainted in detail with the duties of other personnel, and be subject to aiding wherever the rush is greatest in a co-operative spirit without the necessity of specific instruction.

In addition to the foregoing, the personnel of the section will include blueprint operators, cutters and trimmers, photostat operators, helpers, etc. The duties of such personnel are indicated clearly by their functional titles, so that no further elaboration will be given here. The photostat operator or a helper may be assigned to the task of distributing consumable engineering supplies and stationery to the design personnel, such distribution taking place weekly and upon written request on prescribed forms.

In carrying out the work of the blueprint and record section, proper equipment is essential. It is false economy to use anything but the best of modern specialized equipment and materials, as a lost or mutilated tracing or other original, scattered information, or unreadable blueprints represent economic losses which need not be tolerated.

Blueprints or any other reproductions should be clear and legible, for no matter how clear and attractive the tracing, it is only its reproductions that reach the shop and production facilities. A tracing often represents the investment of hundreds of dollars, all of which avails nothing if the reproduction is poor, and yet the difference between a good and a bad print may be only a matter of a few cents spent intelligently.

Plan filing equipment has been discussed previously in relation to drawing sheet sizes. It remains but to add that the standard sizes discussed, and many special sizes, are available in both wood and metal cabinets. Steel cabinets are preferable due to their indestructible qualities and their resistance to atmospheric conditions,

Fig. 3—Shearing table especially useful for production trimming of prints, etc.

obviating the shrinking or binding of drawers, and to their fire-resisting qualities.

Modern practice demands more than a place to file drawings, tracings, vandykes, etc. It demands that the material so filed will be subject to a minimum of crumpling, tearing and curling. It demands also that when filed the contents will be protected from ordinary fires and from dust. These things are essential. Properly designed sectional plan filing cabinets are equipped with drawing protectors which prevent tracings from slipping out of their drawer; also they prevent any friction between the contents of their drawer and the drawer above, and keep out dust.

Vertical Cabinet Is Solution

For filing large drawings, tracings or sets of plans, where it is not desired to roll them, the modern vertical plan file is the logical answer. These files are generally equipped with some 26 binders, each binder taking 100 sheets or more. Plans are directly arrangeable without the necessity of punching holes or binding them. When any particular drawing or set of plans is wanted for reference, the correct binder is located by the label holder and lifted from the rack. The binder is then laid on a table and the plans paged through until the correct one is found. If any plans are to be removed the screw can be loosened. Binders may be replaced readily in the cabinet after use.

For true economy in blueprint production, a continuous automatic blueprinting machine such

as that shown in Fig. 2 is a real investment. Such a machine will produce blueprints, negative (vandyke) prints, blue line prints and brown line prints. Tracings are laid face down upon a continuous roll of paper feeding at the front of the machine, and are carried upward around a semicircular segment of plate glass, past a bank of arc lights. After the exposure has been made, tracings are returned automatically into the tray at the front of the machine, while the prints on the continuous roll of paper pass through the machine for the subsequent operations of washing, potashing and drying. The paper is then rolled up automatically in loose cylinder form at the rear of the machine for convenient cutting and trimming. These machines have a controlled speed range of from 4 inches to 12 feet per minute which adapts them to long run high speed production, yet they also can handle single prints economically.

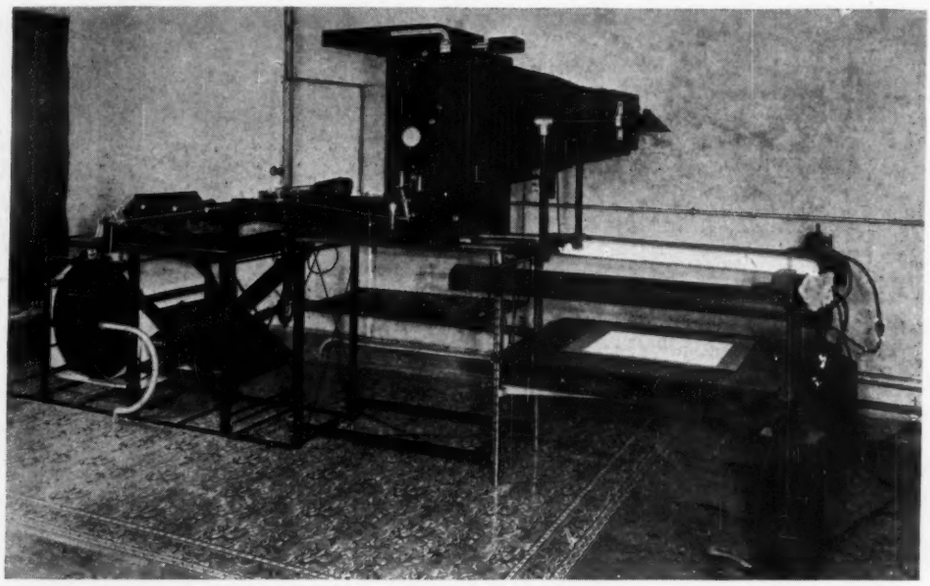


Fig. 4—A photographic copy-recording or photostating machine which will reproduce blueprints, illustrations or even small machine parts

The usual process of making blue line prints (white background with blue lines) with regular blueprinting equipment such as the foregoing, is first to make a negative print from the tracing. After the negative has been washed and dried the blue line print is made from the negative (vandyke) print. Where greater speed is required and blue line prints are used exclusively, special direct blue line equipment may be installed which eliminates the negative print, the blue line prints being made direct from the tracing.

Vertical Machine Has Advantages

Where blueprinting demands are not continuous but fluctuate widely, so that occasional use of the machine is the order of the day, a vertical electric blueprinting machine and sheet washer is available which provides a suitable installation.

In purchasing blueprint paper much can be gained by properly co-ordinating the paper with the operating conditions. Merely buying blueprint paper from the lowest bidder is false economy.

Suitable Blueprint Paper Necessary

The type of machine used, current and voltage information, desired operating speeds, ink tracings, pencil paper tracings or pencil cloth tracings all influence the type of blueprint paper to be used. A proper study of this problem, with a consequent standardization on an established grade of paper, pays real dividends.

For making facsimile copies of anything written, printed, typed or drawn, where the original is not on transparent material, a photographic copy-recording machine, such as that shown in Fig. 4, is employed. This process, sometimes referred to as "photostating," finds innumerable uses in an engineering department. Blueprints of foreign drawings, illustrations, documents of any kind or color whether written, printer, typed or drawn, small machine parts and other flat objects are quickly and accurately copied by such a machine. Such copies can be made the actual size of the machine, or enlarged or reduced at will.

In operating the machine, the camera is first loaded with sensitized photographic paper supplied in rolls. Chemicals are dissolved in water and poured into the developing and fixing receptacles in the body of the camera. The subject to be copied is placed on the copy holder and the exposure made by pressing a lever. The turn of a crank pulls the exposed sheet into the developing solution and a half turn of another crank severs it from the parent roll. After development, the turn of a third crank transfers

the print to the fixing bath and the copy is made. After remaining in the fixing bath a sufficient time, the machine washes the prints in running water and dries them for use.

Table Trimming Shears Desirable

For trimming blueprints, photostats, etc., blueprint table trimming shears as illustrated in Fig. 3 are avaliable. These will cut fifteen to twenty sheets to uniform size at one time and are provided with stationary scales at each side for measuring. They are a great economy where production trimming is a necessity.

In order to instill a proper appreciation of reproduction costs into an organization, an analysis similar to that reproduced above should be prepared for all processes. While individual costs will be influenced by current prices, type of equipment, different localities, or by the fact of whether the work is done within the organization or obtained from a commercial concern, such a chart will serve its purpose if it merely indicates the general average relative costs. In fact an index number of one, for the lowest cost, with relative numbers for the other costs, would serve as well. Particular attention is called to the significance and possible saving in costs by the use of the gelatine and photo-litho process where additional original tracings are required, as compared with retracing costs and the possibilities of introducing errors through retracing.

Proper administration of a design department is after all the continual solving of many detail problems, each somewhat different from its predecessor and each finding its greatest single asset in the application of common sense. Rules and regulations are but a convenient method of expressing the result of past experience and should never become strictly traditional. There is without doubt a distinct advantage in uniformity of procedure, but where the problem is unusual, the possibilities of short cuts founded on common sense always should be carefully weighed before the regular procedure is authorized. Departures from custom knowingly entered into represent real supervision just as variations discovered after completion, and with no intentional purpose, represent poor supervision.

RELATIVE REPRODUCTION COSTS

Process	Type	Color		Reproduced on	Price in cents per square foot	
		Line	Background		First copy	Additional copies
Blueprint		White	Blue	Paper	3½	3½
				Cloth	20	20
Blue Line		Blue	White	Paper	16	6
				Cloth	35	25
Vandyke	Negative	White	Brown	Paper	10	10
				Cloth	25	25
	Positive	Brown	White	Paper	20	10
				Cloth	35	25
Dazo		Red	White	Paper (thick or thin)	6	6
Gelatine		Black	White	Cloth (flat lay)	35	27
				Cloth (curled)	30	22
Photo-Litho		Black	White	Cloth	70	70
Photostat	Negative	White	Black	Paper	25	25
	Positive	Black	White	Paper	50	25
Photograph (regular)	Negative	White	Black	Paper	75	..
	Positive	Black	White	Paper	1.00	25

Conclusion of the Series

Finally, the opinion may be expressed that while design and engineering work were formerly clearly defined by the distinct lines of delineation of mechanical engineering, civil engineering, electrical engineering, etc., the current trend is toward a collosal combination of the basic knowledge of all these divisions, which as far as organization and supervision are concerned may well be termed "human engineering." There is one very distinct difference in this latest branch of engineering, which is that your degree can be obtained but from one university—the School of Practical Experience, Anywhere, U. S. A. The "lab" classes are held in your own design department, and the text books are the technical magazines and catalogs of your own and correlated industries.

Does The Designer Appreciate His Influence on Civilization?

By John W. Marshall

MACHINE designing had its beginning in prehistoric times and therefore is so ancient that the actual dates are unrecorded. Crude devices unearthed by the anthropologists attest amply indeed to the existence at that ancient period of the germ of a profession dedicated to the design of machinery for the benefit of mankind. Histories and mechanical books resound with examples of these early attempts. We find primitive designers in the early stages of civilization perfecting means of augmenting mankind's efforts by the forces of nature; we note how Archimedes raised water by means of a screw; we read with wonder of Hero's primitive impulse-reaction turbine; and we look in amazement upon the promises and prophecies of the future.

The machine designer is essentially a man of ideas. His task it is to create—a job calling for a fertile and active mind—while the profession as a whole has yielded to civilization more than any single agency it is possible to name.

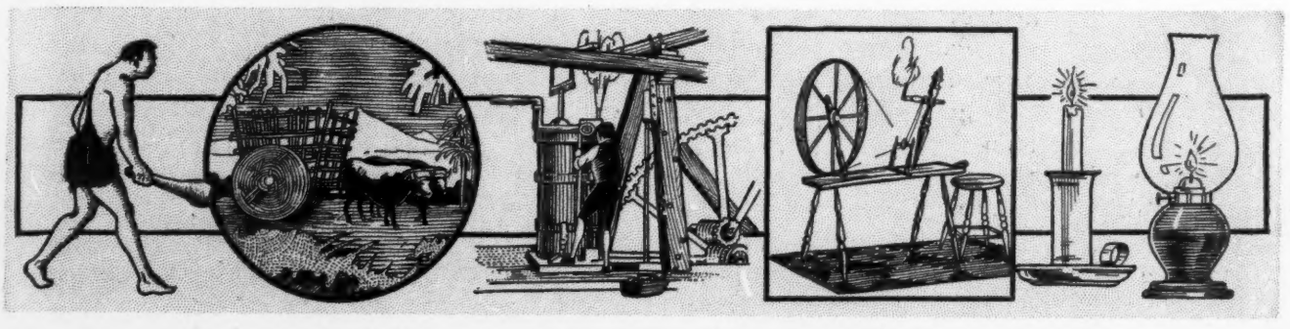
Wide Scope Is Offered

The accepted meanings of the words "machine" and "design" convey quite acceptably the broadness of the scope of this important branch of engineering. As defined by Webster, we have: *design,* to create or produce; to invent: *machine,* a construction in which a combination of moving parts or simple mechanical elements work together to transmit or modify force, or to apply it in the production of some desired mechanical effect. We look up "invent" and find this: *invent,* to discover, to contrive or produce for the first time, to frame by the imagination, to fabricate mentally.

Defines the Machine Designer

Hence, we are forced by definition to the conclusion that the machine designer is one who invents, who discovers, that he contrives or produces for the first time, that he frames by the imagination, that he fabricates mentally a construction in which a combination of moving parts or simple mechanical elements work together to transmit or modify force or which applies force in the production of some desired effect. Broad in scope we must admit, but this only indicates the greatness of the opportunities presented and the vastness of the field open to those seeking a worth-while field.

Of course, the designer may, if he choose, look upon himself as a mere draftsman, as one who works at a drafting board, engaged in carrying out or drawing to scale the ideas of another, but the writer of this article is one of those who look upon him as a creator in the broadest sense, as a leader in thought, as one engaged in the development of the world's resources, as one who finds ways and means of turning into a useful state the latent physical potentialities of nations by the transformation of their resources into a form suitable to the needs of mankind. Hence, in the true sense the designer is the primary factor of the betterment of national conditions, a



man of marked resourcefulness, of professional skill, of indomitable courage. He is, in fact, a dreamer with the vision that gives to airy nothing a real existence, with the ability to see not only the need but the remedy even before the former arises, with the power to picture in the eye of his mind precisely how the undeveloped work will appear when completed, and with the technique to convey this picture to others by means of drawings and other methods.

Progress Has Been Rapid

The above tells briefly the job of the designer of machinery. Far-reaching and ephemeral it must have looked to the world at large less than a century ago—but the steamboat came, as did the locomotive, the telegraph became a reality, then came the telephone, means for fashioning ores into delicate parts of intricate machines were produced, design problems of production were encountered and mastered, the radio was designed, and airplanes and airships were developed.

A century is a small length of time when compared to those that have come and gone and yet no less than a century ago the business of machine designing was regarded as in its infancy. Was it rightly so regarded or are we today but entering upon a new era of design, of development that will lead to no one knows where? What will the chronicles of a century ahead relate? To some of us it may seem that so much has been done that the future could well take care of itself.

Tools Revolutionizing Industry

Such indeed was the feeling in the wide realm of cutting metals when in 1898 Frederick W. Taylor brought out high-speed steel and demonstrated the practicability of cutting metals with speeds so great and feeds so deep, even though the cutting tools attain a red heat, that the machine tools then in existence could not stand the severe strains imposed upon them. The result was a revolution in the machine tool industry, necessitating a complete redesign to meet the new conditions. But, today, we read numerous notices of new steels being employed that appear to be destined to cause another revolution in this major industry. Such is the march of progress.

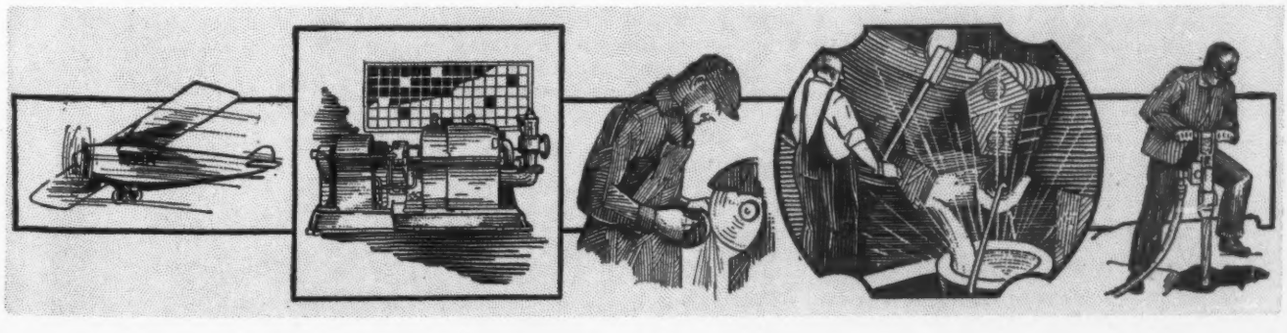
Paradoxical as it may seem, it is not too much to anticipate that means undreamed of are waiting man's discovery and application—means that will make these marvelous accomplishments seem crude indeed—in order to create entirely new methods involving the design of new types of machinery. For when one considers that the tiny, invisible electron is now known to be electricity, matter, energy all in one, it no longer can be said that one is a mere dreamer to think of devising ways of fashioning the myriads of these tiny elementary constituents of all things into any desired combination where and when he chooses.

We have dwelt upon the foregoing in order to present a picture of the broadened outlook of machine designing by the presentation of the fact that the machine designer has emerged from the narrow bounds that formerly hemmed him in.

Old Rule Is Suspended

If a piece fails, make it heavier, the rule of past decades, has been superseded by the exact laws of mechanics together with the considerations of all that the sciences of physics, light, sound, electricity, metallurgy, at first thought entirely unrelated to the subject under consideration, contribute. The man who played a "hunch" has been displaced by the fellow who knows.

Instead then of accepting the conclusion that the ways and means of design are now well-known and conquered, would not the best policy be to realize how much more there is to know, how elementary have been our achievements, and to gird ourselves for the task and prepare ourselves and the profession as a whole to more adequately cope with the many new problems that are constantly arising, to bring to our assistance, more than ever, the powerful tools of the mathematician, the precise knowledge wrestled from nature by the modern physicist, metallurgist, and chemist, and to bring about and emphasize more and more the co-operative channels now being established between our leading manufacturers, colleges and technical societies.



Safety of Bearings Is Determined By Oil Film Thickness

By G. B. Karelitz

SATISFACTORY and efficient performance of plain bearings of various types depends to a large extent on correct design from the standpoint of lubrication. Of value to designers therefore is the information contained in a paper dealing with the performance of oil-ring bearings, prepared by G. B. Karelitz, research engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, and presented at the recent annual meeting of the American Society of Mechanical Engineers. In the accompanying abstract of Mr. Karelitz's paper, special attention is paid to the method discussed for arriving at the safe limit for these bearings as determined by the minimum oil-film thickness.

OIL-RING bearings still hold an important place in the design of rotating machinery. It is true that in machines running at high speed, where the amount of heat created in the bearings requires artificial cooling, forced-feed lubrication is gradually replacing oil rings, the practice of cooling the bearing shell proper thereby being abandoned. But the oil-ring bearing is a self-contained unit requiring little attention or maintenance and is desirable wherever it can be used. Efforts are therefore made on the one hand, to raise the capacity of these bearings and, on the other hand, to be able when designing a new machine to predetermine closely the performance of the bearings in order to decide whether an oil-ring type will be adequate. As a result, an investigation partly reported in the present paper has been undertaken.

The paper deals with the questions of safety of a bearing and the heat balance in oil-ring types, these questions being basic to the performance of any bearing. The author realizes that many other considerations must be taken into account when designing a bearing, such as strength, oiltightness, dustproofness, convenience of inspection and maintenance, ease of manufacture, etc. Many of these properties have been considerably improved recently in line with the generally stricter demands of modern industry and the serious competition offered by ball and roller bearings.

The general idea of a load-carrying oil film is now well known and does not need much space here. It will be sufficient to mention that the existence of such a film is caused by the viscosity of the lubricant and by its ability to adhere strongly to the rubbing surfaces of the shell and the journal. Radial clearance provided in the bearing automatically causes the existence of a wedge-shaped film between the journal and the shell. The oil, being entrained by the journal into the clearance, tends to be compressed; due to its practical incompressibility, strong currents and countercurrents of oil are created in the film. Shear rate in the oil is naturally high, the gradient of velocity from the journal surface to the shell surface being of the order, say, of 500,000 feet per minute per inch of oil film, and the viscous resistance of the oil to this motion creates high hydrostatic

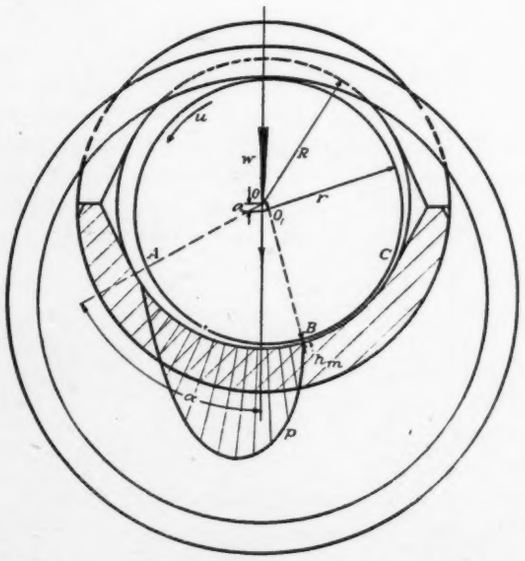


Fig. 1—Diagram of standard oil-ring bearing

pressures, quite ample to carry the load on the journal.

Under these conditions, the only frictional losses in the bearings are caused by internal friction of the lubricant. This friction is only a fraction of that which would be present should the load be carried by direct contact between the rubbing surfaces, even in the case when such surfaces are covered by a good "greasy" (or "oily") film of lubricant.

It is therefore important to be in a position

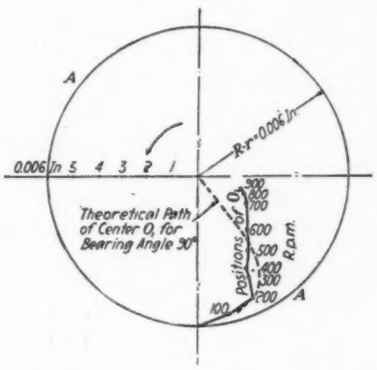


Fig. 2—Enlarged view of theoretical path of the journal center

to evaluate the minimum thickness of the oil film when designing a bearing in order to be certain that this thickness is above the safe limit for the type of bearing under consideration. Now, this limit may vary considerably, depending on the kind of service, the finish of the surfaces, and probable misalignment or thermal distortion of the bearing. In finely bored small bronze bushings a film of the order of 0.0001-inch will be sufficient, while for ordinary commercial bearings, with a steel shaft and a babbitted shell, a thickness of oil film above 0.00075-inch should be maintained if the speeds are high, and a thickness not below 0.0004-inch in all other cases. This limit was checked on several occasions and appears to be well founded.

Designer Should Check Oil Film

It will be shown later that the determination of the minimum thickness is a comparatively simple matter, and the safety of a bearing should be checked by a designer on this basis rather than by empirical formulas which are usually obsolete a few years after being established. For example, there is one formula giving for the safe limits of bearing design $pv = 50{,}000$, where p is the pressure on the projected area in pounds per square inch and v is the peripheral speed in feet per minute. Bearings are now operating successfully where $p = 100$ and $v = 2100$, pv being above 200,000.

An oil-ring bearing of standard construction shown in Fig. 1 will now be considered. Let

$D - d$ = clearance (play) in shell; $R - r$ = radial clearance

$m = (D - d)/d = (R - r)/r$ = clearance ratio; $R - r = mr$

h_m = minimum oil-film thickness

a = linear eccentricity between center O of shell and center O_1 of journal in running position

$c = a/(R - r)$ = eccentricity ratio; $a = (R - r)c$

p = pressure in the oil film at any point

h = the thickness of the oil film at this point

W = total load on bearing

L = active load-carrying length of bearing between end grooves

$P = W/dL$ = pressure on projected active area

α = angle between entering edge A of oil film and direction of load W. (In case of symmetrical bearings with vertical load on the journal, the bearing angle $AOC = 2\alpha$.)

u = peripheral velocity

N = revolutions per minute of the journal

$\omega = \pi N/30$ = angular velocity in radians per second

μ = absolute viscosity of the oil in the oil film, assumed to be constant throughout the film

Z = the viscosity measured in centipoises.

Assume for the time being that the oil film is sealed at the bearing ends, i.e., that there is no end leakage, making the conditions therefore identical in each cross-section of the bearing. The middle strip of the bearing, a unit of length (inch, centimeter) wide, carries then a load $w = W/L$. If equilibrium exists, the resultant of all

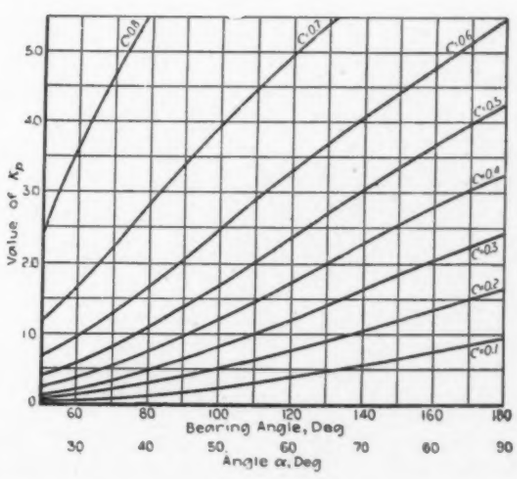


Fig. 3—Chart for determining eccentricity ratio

oil pressures p on the journal strip is equal and opposite to w.

The center O_1 of the journal can take any position inside a small circle described around O by the radius $(R—r)$ (see Fig. 2), and the journal

will adjust itself automatically to a position where this equilibrium exists.

The pressures p are, however, determined completely by the viscosity of the oil μ, the velocity u,

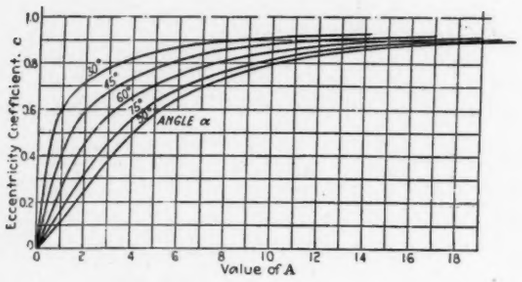


Fig. 4—New chart replacing Fig. 3

and the shape of the clearance. These values are interconnected by the equation

$$\frac{dp}{dx} = -6\mu u \frac{h - h_1}{h^3}$$

where h_1 is a constant the value of which happens to be larger than h_m but smaller than h_a.

It was observed on numerous occasions that the oil pressure at B, the point of minimum oil film thickness, is very near zero, the pressure in BC where the film is divergent being slightly negative. A vacuum up to several inches of mercury may be observed even in forced-feed bearings when the oil is supplied under a low head of, say, 10 pounds per square inch. The assumption that the pressure p_B at B is equal to zero in oil-ring lubricated bearings is therefore justified. On the other hand, under usual conditions of bearing construction, the pressure at A is quite low and the pressure p_A also may be taken equal to zero. It is true that pressures may be observed sometimes under the upper cap of the shell or in the relief at A, but these usually are small when compared with the pressures in the oil film proper and they do not affect appreciably the values of p.

Pressures Can Be Determined

With $p_A = p_B = 0$, the pressures p can be evaluated from the differential equation referred to for each position of O_1. The pressures p, when combined vectorially, give for each position of O_1 the value of w and its direction, i.e., the angle α between w and the entrance edge A. As a rule, the shape of the pressure curve p is such that the angle between w and B is smaller than α, the difference growing with the increase of the linear eccentricity a.

The pressures p are proportional to the value $\mu\omega/m^2$, the coefficient of proportionality being determined only by the relative position of O_1 with respect to O, while the load-carrying capacity of the strip of unit width is

$$w = K_p r \frac{\mu\omega}{m^2}$$

where K_p also is determined only by the position of the journal. By tabulating the values of w and α for a large number of positions O_1 and by graphical interpolation, the relation between K_p, α, and $c = a/(R-r)$ can be represented in a chart shown in Fig. 3.

In actual bearings the end leakage causes a gradual decrease in oil pressure from the middle section to the ends where it is zero. Experimental data by Lasche, Kingsbury and others show that with normal ratios of length to diameter of from 1 to 3, the pressure distribution lengthwise may be taken as parabolic. The load-carrying capacity of the bearing is then

$$W = \frac{2}{3} wL = \frac{2}{3} K_p L r \frac{\mu\omega}{m^2}$$

Since $W = PLd = 2PLr$, $P = {}^1/_3 K_p \mu\omega/m^2$. With a given load, load direction, speed, viscosity, clearance, the coefficient $K_p = 3Pm^2/\mu\omega$ can be found, and from Fig. 3 the value of c will be determined. The linear eccentricity OO_1 is $a = c(R-r)$, and the minimum thickness of the oil film is $h_m = (R-r) - a = (1-c)(R-r) = (1-c)mr$.

The chart in Fig. 3 is not convenient. It has been rearranged and extended partly on the basis of the calculations of Guembel, partly by extrapolation, and the chart in Fig. 4 was drawn. The

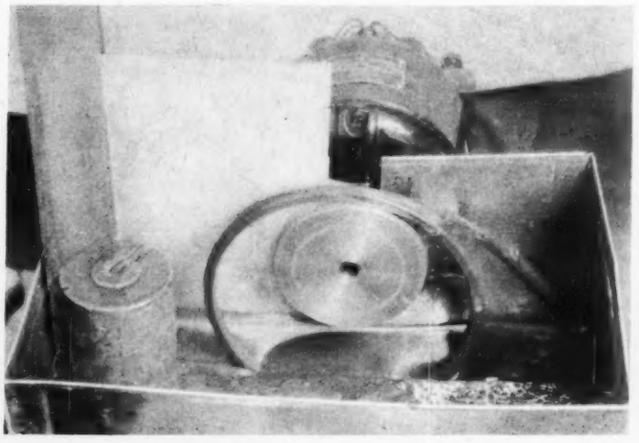


Fig. 5—Test carried out with seven inch oil ring, one inch submersion

coefficient K_p is replaced by A, allowing for the diverse units used in engineering; P is measured in pounds per square inch, and $\omega = \pi N/30$, where

N is the revolutions per minute. The absolute viscosity μ should be measured in (pounds per square inch of rubbing area) per (inch per second per inch of film thickness) or in lb. sec./in.^{2}, while it is given usually in centipoises, where 1 poise = 1 (dyne per square centimeter of area)

Fig. 6—Test for determining heat dissipation from actual bearing

per (centimeter per second per centimeter of film thickness) = 1 dyne sec./cm^2; the viscosity in centipoises being Z, $\mu = 1.45 \times 10^{-7} Z$.
Now

$$P = \frac{1}{3} K_p \frac{\mu\omega}{m^2} = \frac{1}{3} A \frac{ZN}{m^2} \frac{1.45 \times 10^{-7}\pi}{30}$$

therefore

$$A = 198(1000m)^2 \frac{P}{ZN}$$

The value ZN/P, which is a non-dimensional number, may be called the characteristic number of the bearing. It not only defines the running position of the journal in the shell but determines the running friction in the bearing as well, as has been pointed out repeatedly in literature.

Example Is Conclusive

As an example, a slow speed oil-ring bearing of the following specification will be considered: diameter $d = 11$ inches; full length, 25 inches; end grooves occupy 1¼ inches on each end, giving an active length $L = 22.5$ inches; clearance on diameter $s = 0.0125$ inches; or $m = 0.0012$; the relief at the split is 15 degrees on each side; load $W = 35{,}400$ pounds directed downward; speed of rotation $N = 187.5$ revolutions per minute. The oil used was machine oil having a viscosity of 320 seconds Saybolt at 30 degrees Cent. and 50.5 seconds Saybolt at 100 degrees Cent.; specific gravity 0.86. Pressure on the projected area of the bearing is $P = W/dL = 141.5$ pounds per square inch. The temperature rise in the oil film may be assumed to be 20 degrees Cent. above the ambient temperature; with a possible air temperature of 40 degrees Cent., the temperature in the oil film will be 60 degrees Cent., or $Z = 17.0$ centipoises. The coefficient A equals

$$198 \times 1.2^2 \times \frac{141.5}{17 \times 187.5} = 12.7$$

The angle α in this case is 90 degrees — 15 degrees = 75 degrees. Entering $A = 12.7$ in the chart (Fig. 4), the curve $\alpha = 75$ degrees, gives $c = 0.86$. The minimum oil-film thickness is then

$$h_m = (1 - C)(R - r) = 0.14 \times \frac{0.0125}{2} = 0.0009 \text{ inches}$$

This bearing works therefore within safe limits.

It is obvious that oil-ring-lubricated bearings work in the best conditions when the load applied to the journal is directed downward or at a small angle to the vertical. Should the load be directed upward, as may happen with an industrial motor with a belt or gear drive, the slot or slots through which the oil rings pass divide the bearing into two or more parts. In fact, the shaft may be considered as supported by several separate bearings. In a bearing of a length equal to two diameters, or longer, with one oil ring at midlength of the bearing, the top half presents two bearings each one diameter long. Such bearings work quite efficiently, and the performance of the bearing as a whole is practically identical in any direction, provided oil-distributing grooves are cut properly. In shorter bearings, the oil film will be inherently thinner with loads acting upward than when the same loads act downward upon the journal. This fact must be remembered when rating oil-ring bearings for general service.

The author realizes that the discussion brought forth in his notes may be criticized because of a number of assumptions and rough approximations. Unfortunately, all mechanical engineering consists, when applied to actual designing, in an approximate application of "exact science." Exact analysis is a powerful tool, but its application always must be controlled by sound judgment of the designer. This personal element may be eliminated only by an accumulation of facts and observations which gradually will narrow the range of the correction coefficients employed in the reported computations.—G. B. KARELITZ.

PROFESSIONAL VIEWPOINTS

Publication of letters does not necessarily imply that MACHINE DESIGN *supports the views expressed*

Comments from Our Readers. Machine Design Will Pay for Letters Suitable for Publication

Can Design Work Be Scheduled?

To the Editor:

IN REPLY to the letter by Mr. Goetz in the January issue of MACHINE DESIGN in which he asks the question as to whether designing and detailing can be scheduled, I wish to advise it certainly can be. In fact, this is being done in hundreds of shops throughout the United States.

Anyone who has been in the automobile game will recognize this: Executives, for several days, have meetings behind closed doors; department heads have secret sessions; all at once the news is whispered about, "A new light six is to be designed and built. First car must be running in — days. Full production must be reached in — more." Woe be unto the engineering or tool design departments if they fall down on the schedule.

Just because the automobile manufacturers must meet their schedule machine tool builders also must work to schedule. When the order comes for a special automatic machine to be delivered on a certain date it simply must be done.

Failures to meet schedules are usually due to three things, first; incomplete and incorrect data from the development department. Second; injudicious scheduling. Third; poor management in the engineering department.

Development design can, but should not as a general thing, be scheduled. Many designs in this department are tentative. It is an exceptional designer who can conjure up new and clever ideas as fast as he can put them on paper. This department should have time enough to develop ideas without having to use a hypodermic needle.

Injudicious scheduling is due to inexperience and from overestimating the capacities of the various departments.

Sometimes proper emphasis is not placed upon the order in which the drawings should be released. Usually they are released in the following order; complicated castings, forgings, punch and die work, simple castings, and screw machine parts. This order naturally is varied according to the product.

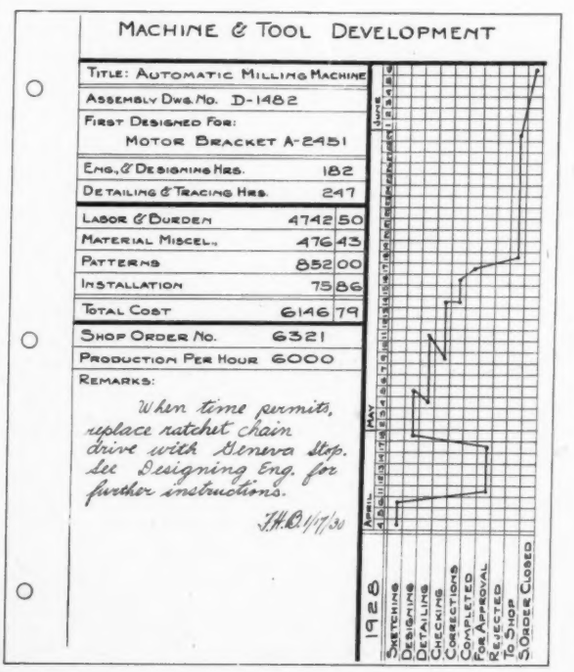
Given a reasonable schedule, and executives and designers who "know their hardware," there is no reason why designing and detailing should not be turned out according to a predetermined time limit.

—BURTON MATTHEWS,
Richmond, Ind.

Keeping Accurate Cost Records

To the Editor:

PRESENT day manufacturing standards require precise records and unless great care is exercised in the formulation of these records, the cost of maintaining often more than offset their value.



With this in mind, the chart illustrated herewith was laid out and has been in use for some time. It measures standard letter size, 8½ x 11, which affords filing in letter file or in loose leaf book.

Where it is necessary to elaborate on the items

of cost, space for so doing may be taken from that which comes under the heading of Remarks.

Further than this, the chart is self explanatory.

—GEORGE T. CHAPMAN,
Detroit.

Raising Strength by Cold Working

To the Editor:

THE phenomena referred to by Dr. Moore in his article "Study of Fatigue of Metals," page 35, November, 1929, issue of MACHINE DESIGN is not new, although in the actual tests as conducted by Dr. Moore the results have come as a surprise to many designers and engineers because they are couched in language different from any used heretofore.

On page 36 Dr. Moore states "Understress raises the endurance limit, overstress lowers it." I believe that this statement should be supplemented by the word "continued" before the word "overstress," unless Doctor Moore has not made tests that would show this phase of the phenomena.

In elaborate tests carried on in England over 40 years ago by a noted firm of gunsmiths and later on recorded in a house organ, *Kynoch Journal* put out by Kynoch's, an ammunition manufacturing company, it was demonstrated that a rifle barrel could be made much stronger and made to endure greater ultimate stresses of pressure without final rupture, if the pressure generated by the first fired charges or proof charges was gradually raised by small increments from the theoretical safe charge to slightly above the elastic limit of the metal composing the barrel, so that the chamber of the barrel was stretched (cold worked) slightly and given a set of from .012 to .005 inches above the finished dimensions. When this was done the charge could be reduced to the theoretical safe charge and a continued use of this could be had with safety, not considering the tolerances that must be allowed because of variances in the strength of the powder, in powder weight and the weight and fit of the bullet in the barrel. All this would tend to increase the resistance against the powder gases and raise the working pressure within the barrel of the gun: also charges could be fired later that would not have been safe with the barrel in its original state. This fact of added strength by working has been applied to the manufacture of big guns by giving the main tube a decided set by hydraulic pressure before the outer bands are shrunk on.

In Dr. Moore's article I think it would be better also to designate "endurance limit" as the ultimate elastic limit because when that point is reached the metal begins to weaken and at last failure results. I also think that the method of attack is but a re-incarnation of the metallurgist's theory of cold working of metals and that much of advantage could be obtained from a perusal of that theory and a study of the fractured test pieces by Dr. Moore's staff to ascertain if the metal does not show many slip bands throughout the worked area. If he will carry the tests to what he later calls the "overstress" for but a few cycles, then return to his original "understressing" or "teasing" treatment, I believe that he would find a remarkable addition to the endurance limit, just as the added endurance limit of his tests is above the original endurance.

In designing machinery I have always kept this fact in mind as it was brought out in my earlier training as a ballistic engineer, that the stresses could occasionally be raised above the natural elastic limit and if then reduced to a safe limit there would be no danger of failure; also that the part again could be stressed to the original limit and yet no indication be shown in the part as it would then be actually stronger than originally from the effects of the working stresses applied to it. In this working of parts, if the stresses do not exceed the elastic limit by too great a margin the result will be a stronger part than originally, but should the piece be too strongly stressed small surface checks may be opened up that will later cause failure of the piece.

—G. G. WILLIAMS, M. E.
Cincinnati.

Submit Drafts of Recommendations for Drawing Room Practice

Drafts of proposed standards for drawings and drafting room practice now are available on loan from the American Standards association, 29 West Thirty-ninth street, New York.

In the draft of the proposed practice for indicating bolt heads, nuts and screw threads, it is pointed out that the two methods now in use to indicate screw threads have been retained. The use of right and left slant lines used for showing right and left hand threads, however, has not been recommended.

In another draft, on the method for indicating dimensions, illustrations of recommended and non-recommended methods are given. The draft includes a recommendation that dimensions should not be duplicated in various views of a part, and that only a sufficient number shall be given to make it possible to produce the part.

A third draft, on lettering, indicates that the vertical type of lettering appears desirable, this already having been widely adopted.

MACHINE DESIGN

A New Motive for Design

Editorial

WHY are machines? When one submits this question to engineers, he receives a varied assortment of replies. One member of the profession may say that the urge to reduce the cost of production is the chief incentive for creating machinery. Another may declare that the guiding impulse is to improve the quality of product. Still another may cite the desire to improve service to customers as the dominant influence. But reduced to a common denominator, these answers all place the major emphasis on efficiency.

THERE can be no valid objection to this motive. Practically every phase of modern business is governed by the urge to do things efficiently. Nevertheless, there is a strong undercurrent of sentiment throughout the world which is slowly but surely altering our conception of this fetish we call efficiency. More and more we are thinking of efficiency in terms of its effect on the individual, rather than in the measure of its purely material advantages.

ONE can detect this shifting of thought in a number of recent developments. Persons in high authority are placing increasing emphasis on "human engineering." The economic theory that high wages and improved standards of living for workers mean massed purchasing power and more widely distributed prosperity is generally accepted as sound. Ten years ago none but a fanatic would have proposed a five-day week. Today opposition to it is neither general nor emphatic. As pointed out in the leading article in this issue, all forces of public opinion are thinking in terms of human welfare to a greater extent than ever before.

THESE manifestations of a changed attitude toward the human element in industry suggest that the machine design profession might seriously consider its work from a new perspective. What would happen, if in designing a machine, the welfare of the operator were considered as seriously as is its mechanical or productive efficiency? What would result if quietness of operation; safety; convenience in operation, maintenance and repair; and other features contributing to the welfare of the worker were placed on a par with speed, power delivered per unit of power input and other items of technical perfection?

IN SHIFTING part of the emphasis from material efficiency to human efficiency, machine designers not only will weaken the arguments of critics of the "machine age," but they probably will find that this new motive in design will open to them unforeseen opportunities for improving machinery.

New Uses of Materials

TWO unusual applications of well known materials of machine construction are mentioned in this issue. The use of a strong aluminum alloy for the bridge and lesser structural members of a 10-ton crane, as outlined on page 26, suggests the possible employment of this light material in other structures where steel has been the only metal available in the shapes desired. Likewise the achievement of a steel foundry in casting a locomotive bed, including frames, crossbraces, bumpers and cylinders all in one piece, as noted on page 25, is worthy of the attention of designers who are seeking massive machinery beds or frames in which the assembly of smaller parts by bolting or riveting is not desirable. These two illustrations are typical of the steady progress being made in the improvement of engineering materials. Today machine designers are offered a far wider choice of iron, steel and nonferrous metals and alloys in rolled, cast and forged form than ever before. Therefore, engineers who keep informed on current developments are in the best position to profit from advances in materials and their application.

Henry Maudslay and His Engine Lathe

Great Moments in Machine Design—Sixth of a series of original drawings prepared exclusively for this magazine symbolizing the designer's contributions to the progress of mankind.

NOTEWORTHY PATENTS

A Monthly Digest of Recently Patented Machines, Parts and Materials Pertaining To Design

SPEED reduction mechanisms are particularly significant to design. In this field George M. Morison has introduced a ball transmission which relates to means for effecting and maintaining the proper operative relation and relative position of inner thrust roller members with the driving shaft and the gyrating ring which encloses and bears on the rollers. For this he recently was granted patent No. 1,738,662, which has been assigned to Morison Inc., Pittsburgh.

In addition to providing a positive wedging action of the inner thrust rollers which increases with the load on the driven element, the invention embodies simple features of construction in which the wearing elements such as the rollers and the race are accessible readily for inspection and renewal.

The accompanying illustration shows Fig. 1, a vertical sectional view embodying the principles of the invention. Fig. 2 is a transverse sectional view. Comprising the structure illustrated is a housing member 1 having a central opening provided with a journal bearing for rotatably mounting a shaft having a flanged end, 5, to which is secured a roller retaining cage member 6. The shaft and cage 4 and 6 comprise the driven or slow speed element of the transmission.

Rollers 21, 22 and 23 are carried by a cage comprising a pair of side plates 17 which are joined by fixed rivets 18, 19 and 20 to hold them in proper spaced relation. Two of the thrust rollers 21 and 22 are of equal diameter and larger than the roller 23, and thus the ring 32 is subjected to a gyrating or thrust movement. As shown in Fig. 2, all the driving rollers 33 are contacting constantly with the gyratory ring 32 and also with the corrugated face of the fulcrum 35, traveling towards the approaching thrust side of the ring.

The corrugations of the fulcrum member have a radius equal to the diameter of the driving rollers 33 and there are more corrugations by one than driving rollers.

Accordingly the movement of the driving rollers 33 imparts rotation to the cage 6, and the driven shaft to which the cage is attached, in a direction opposite to that of the driving shaft, and at a much slower speed. The frictional grip of the ring 32 and the driving shaft 11 on the intermediate rollers 21, 22 and 23 is effected by the arrangement of the roller bearing pads 24 and 25, which operate to cause the wedging action on roller 22 when the driving shaft 11 is turning in a counter clockwise direction, or 21 if rotating clockwise.

Referring to the diagram of Fig. 3 the reaction tending to separate the inner roller thrust members 21 and 23 is utilized to exert a pull on the roller member 22 to cause the latter to advance into the narrowing space in the direction of the pivot roller 23. This is accomplished by

Fig. 1.

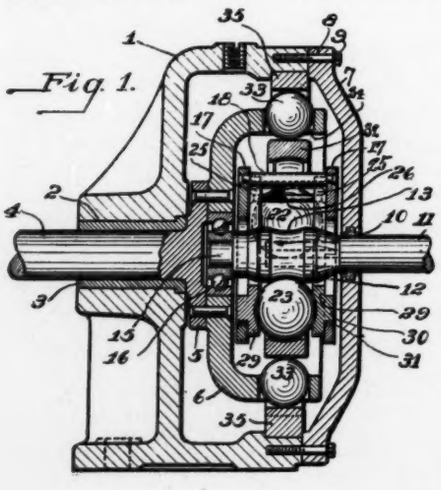
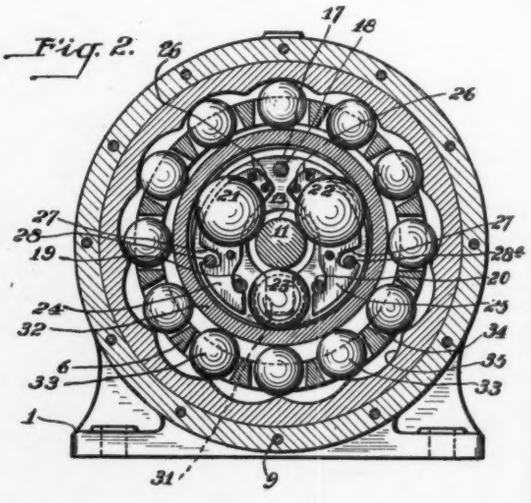


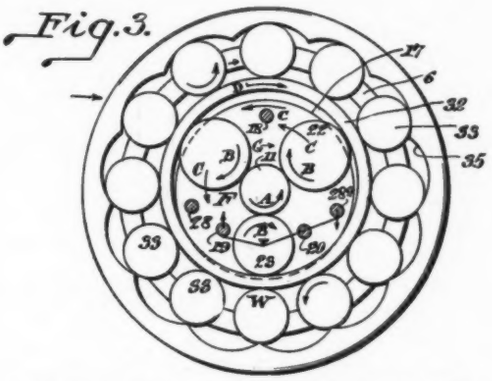
Fig. 2.



Sectional views of the speed reduction mechanism in which a wedging action of the inner thrust rollers, caused by operation of the driving members, imparts motion to the driven shaft in the opposite direction

applying the pull upwardly as shown by an arrow F, exerted by the roller 21 to the fixed rivet 19 of the cage, the rivet 19 engaging the lower portion of the roller bearing pad 24. This upward pull against the cage through the rivet 19 is exerted against the small roller 23 which acts as a fulcrum or pivot point for the cage member.

Since the roller 23 is only pivotally and radially movable relatively to the cage, the latter will tend to move angularly in the direction of the pull as shown by the arrow G, and by engagement of pin 28[a] with the pad 25 the latter will be pulled downwardly carrying the roller 22 with it, thus making roller 22 the wedging roller. Any movement of roller 21 away from roller 23 will cause a greater movement in the same circumferential direction of roller 22. This arrangement at all times assures a positive wedging action for



Diagrammatic illustration of the thrust rollers, driving rollers, driven elements and gyratory thrust ring

the transmission of power from the driving to the driven element without slippage of the inner roller members.

ONE of the problems encountered in gearing used for heavy duty is a tendency for the driving member, such as a pinion, to travel around the periphery of the driven gear and, being restrained by its bearings from accomplishing this, there is a torsional deflect of the pinion. This produces misalignment, increases wear and reduces the life of the gears.

Provisions for maintaining proper alignment and preventing overtravel and end thrust of the meshing teeth are made in the invention of Warren B. Flanders, who recently was granted patent No. 1,742,385, which he has assigned to Westinghouse Gear & Dynamometer Co., East Pittsburgh, Pa. In this unit the meshing gears are supported in rigid bearings which are provided with cylindrical mountings. The rigid bearings prevent overtravel of the meshing teeth and the cylindrical mountings permit the axes of the gears to

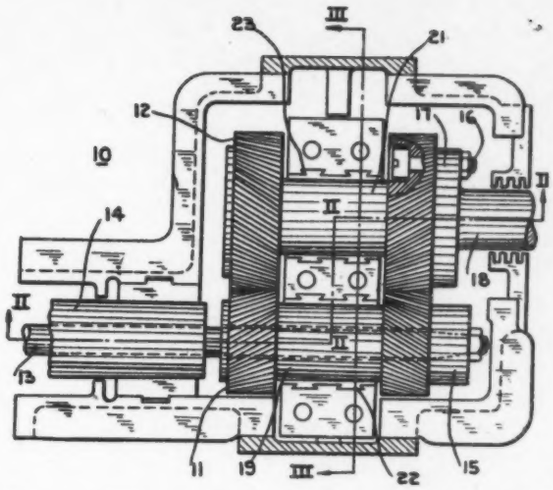


Fig. 1—Plan view of reduction gear with top half of casing removed. Rigid bearings prevent overtravel of the meshing teeth

assume different positions without misalignment or endwise sliding.

In Fig. 1 of the accompanying illustrations is shown a plan view of a reduction gear with the top half of its casing removed. Fig. 2 is a section on the broken line II—II of Fig. 1. The pinion 11 and a gear 12 are provided with spaced rows of oppositely inclined teeth. However, the inventor claims that inclined or helical teeth are not essential and that other types such as spur teeth may be used.

The shaft 13 is supported by the bearing 14 and extends through the enlarged bore of the pinion 11 to which the shaft is connected by a coupling 15. The bore of the pinion 11 is enlarged to provide ample clearance for the shaft. Cylindrical mountings which support the bearings are carried in upper and lower seats 28 and 29 respectively, in cradle structure 31.

It will be seen that while the axes of the gear

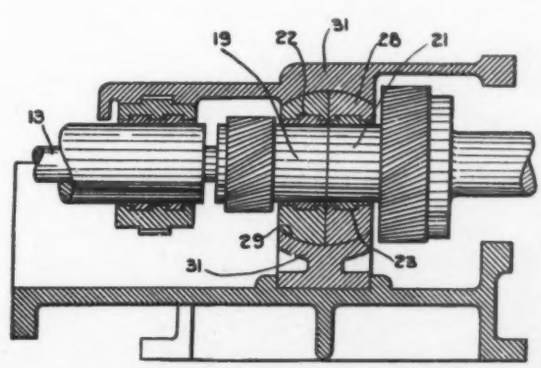
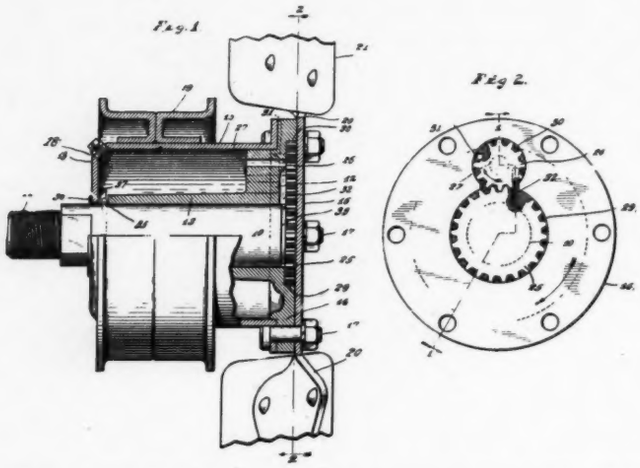


Fig. 2—A section on the broken line II—II of Fig. 1. Cylindrical bearing mountings allow the axes of the gears to assume different positions without misalignment or endwise sliding

members may assume different angular positions they will remain parallel. This unit is particularly useful for installations wherein the axes of the driving and driven shafts do not fall within the same horizontal plane.

A HUB bearing is the subject of patent No. 1,-7,43,712 which recently was granted the inventor, Truman B. Funk, who has asigned it to



Details of hub bearing and passageways for the lubricant are shown in Fig. 1. *In Fig.* 2 *are seen the sun and planet gears which function as a pressure pump for forcing the lubricant from the chamber within the hub to the stud shaft*

Automotive Fan & Bearing Co., Jackson, Mich. The object of the invention is to prevent leakage around shafts, particularly stationary shafts such as the stud type supporting automobile fans.

Lubricant is forced from the chamber within hub 15 to the bearing space between the sleeve 13 and the stud shaft 10. This pressure lubrication is obtained by a gear pump comprising a stationary sun gear 25 and a planet gear 26, which meshes with and travels around the sun gear. As shown in Fig. 2 of the accompanying illustrations, the two gears 25 and 26 are mounted in communicating cylindrical openings 29 and 30 in the front face of the head 14.

A lubricant discharge passage 32 leads from the discharge point where the two openings 29 and 30 meet, and extends downward in the face of the head 14 to the bearing surface of the stud shaft 10, which has a circumferential groove 33 next to the sun gear for distributing the lubricant around the stud shaft.

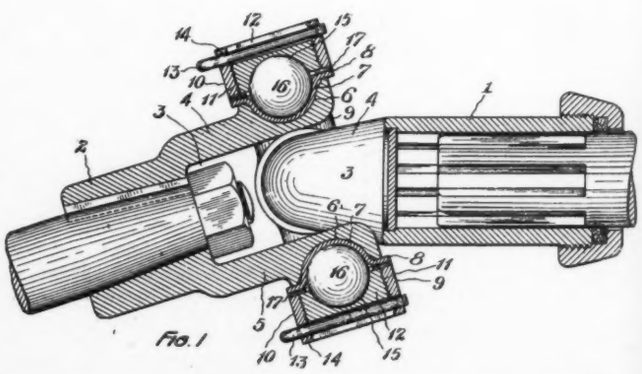
To prevent leakage a simple wire ring 35 is mounted tightly around the shaft 10 and close to the end of sleeve 13 without touching it. Oil traveling along the bearing surface toward the supporting end of the stud shaft encounters the ring 35 and tries to creep over it. The space between the ring and the end of the sleeve 13 is sufficiently small so that oil will be caught by the end of sleeve 13 and thrown outward into the lubricant chamber by centrifugal force.

To further prevent leakage a deflecting member 36 which rotates with the hub casing 15 is provided. As the fan is rotated the lubricant lies against the hub casing throughout the circumference due to centrifugal force. When the fan is stopped the lubricant falls to the bottom of the chamber. The down-flowing film of lubricant on the inner face of the end wall 18 strikes the flange 37 and is deflected, thereby preventing it from reaching the hole through which the stud shaft 10 extends.

AN INVENTION relating to universal couplings recently was granted to George H. Hufferd and assigned to Thompson Products Inc., Cleveland. In the accompanying illustrations numerals 1 and 2 designate the driving and driven members, although it is to be understood that either may be a driving member. Each of these members is bifurcated by a slot 3 to form two arms 4 and 5, which are made thick enough to admit the formation of hemispherical recesses 6 near the free ends.

Surrounding the bifurcated ends of the driving and driven member is an intermediate member 9 consisting of a complete ring having a plurality of enlargements, 10. These enlargements are provided with radially threaded bores 11 adapted to receive externally threaded plugs 12 held in adjusted relation. The plug 12 is preferably of hardened material formed at the inner end with a hemispherical ball bearing surface 15.

In the spherical recesses formed when the parts of the coupling are joined, balls 16 are inserted which serve both as a connecting means between the driving, driven and intermediate members, and as pivotal means to enable the parts to func-



In vertical longitudinal section of the coupling shown above, the balls 16 *fit in the spherical recesses formed when the parts are assembled, and serve as a connecting and pivotal means*

tion as a universal joint. In transmitting the torque from the driving to the driven members there constantly will be a tendency to press the ball seats into snug contact with the balls. Consequently, there is a tendency to take up wear in the joints automatically.

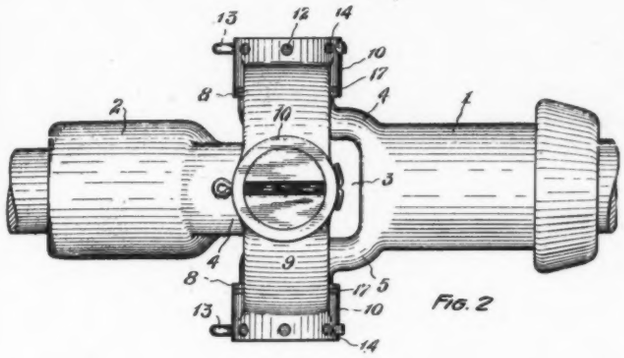


FIG. 2

The assembled coupling as it appears in plan view. Either 1 *or* 2 *may be the driving or driven members, and each is bifurcated as shown at* 3

Review of Noteworthy Patents

Other patents pertaining to design are briefly described as follows:

PAPER-INSERTING DEVICE—1,740,605, for a paper-inserting device for cigarette machine printers. This invention comprises a drum for carrying a continuous paper strip and a means for gripping the leading end of the paper strip at any time while the drum is in motion. Assigned to American Machine & Foundry Co., New York.

LEAF-STEMMING DEVICE—1,740,611, comprises the combination of a pair of knives co-acting to engage the stem between them. The knives are cleaned by a wiper which operates immediately after the knives are separated. Assigned to Standard Tobacco Stemmer Co.

FLEXIBLE COUPLING—1,740,617. Covered by this patent is a flexible coupling which is composed of a sleeve having two sections and a series of teeth engaged to transmit motion from one shaft to the other. A breakable element rigidly connects one section with one of the separable portions of the other sleeve section adapted to be ruptured when a predetermind load is imposed on one of the shafts. Assigned to Poole Engineering & Machine Co., Baltimore, Md.

TURBINE SHAFT BEARING—1,742,256. Covered by this patent is the combination of a container having relatively wide grooves formed in the inner side, bearing strips of hard wood being removably mounted in each of the grooves, and strips of softer material individually interposed between. The softer material engages the adjacent side edges of the pairs of bearing strips to fix them positively in the grooves. Assigned to S. Morgan Smith Co., York, Pa.

FLEXIBLE GEAR WHEEL—1,740,656, for a gear comprising a hub, a rim carried by the hub, lugs on the hub and on the rim and a spring for transmitting torque between the hub and the rim. Bearing surfaces of the spring member engage the lugs. The shape of the bearing surfaces are such that in engaging and disengaging the lugs on the rim and hub there is practically no sliding contact. Assigned to Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

SHAFT SEAL—1,740,682. This invention comprises a shaft, an eccentric member fixed to the shaft, and a fixed wall member having an opening through which the shaft projects. A floating member disposed on the shaft between the eccentric and fixed members, has a lapping sealing surface contact with them. Assigned to C. & C. Engineering Co., St. Louis.

SAFETY STOP—1,740,726, for a combination with a structure mounted to travel along a railway. Track engaging means are connected with the structure, which facilitates flexible support and lowers and raises them in and out of engaging position. Assigned to Wellman-Seaver-Morgan Co., Cleveland.

SHACKLE—1,743,171. A combination of a spring, a vehicle frame, and a cushioning device. The latter comprises a resilient body having internal body face portions in slidable contact relation. Assigned to Pneumatic Appliances Corp., New York.

GRINDING WHEEL SLIDE—1,734,080. "In a machine having a frame, in combination a grinding wheel, a wheel shaft, a slide for said wheel and shaft, said slide being capable of movement in said frame axially of said shaft and having a transverse recess therethrough." Assigned to Greenfield Tap & Die Corp., Greenfield, Mass.

DRIVE CHAIN—1,743,157 for a multistrand chain to run on a sprocket wheel. It has a combination of overlapping link plates arranged in inner and outer strands, pintle parts being of the split joint type so that one part of the joint may engage directly with the sprocket wheel while the other part moves in relation to it. Assigned to Morse Chain Co., Ithaca, N. Y.

ROLLING METAL STRIP—1,744,017 "for the process of making metal strip, which includes subjecting the metal to cold rolling in a plurality of passes, embodying small supported rolls, and subjecting the metal to tension during the rolling operation, thus reducing the metal to materially less than half its original thickness." The rolls are of sufficiently small diameter to substantially eliminate widening the material during rolling under such tension. Assigned to Cold Metal Process Co., Youngstown, O.

CARBURETOR—1,733,282 for "a carburetor, comprising in combination, a body providing a mixing chamber and a passage for air into the chamber, a valve normal tending to close the passage and adapted to open in response to reduction of pressure in the chamber, and a manually operable member for positively closing the valve having an air passage leading into the chamber, said last mentioned passage being open at all times when the valve is free to operate in response to the pressure in the first mentioned passage, and the entrance to said second passage being located so as to be closed by the hand of the operator when the member is manually operated to close the valve." Assigned to Delco Light Co., Dayton, O.

MEN OF MACHINES

Personal Glimpses of Engineers, Designers, and Others Whose Activities Influence Design

FOR his contributions to the design and development of rotating electrical machinery, Rudolf Emil Hellmund, chief electrical engineer of the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., has been awarded the Lamme medal of the American Institute of Electrical Engineers. Mr. Hellmund was born in Gotha, Germany, Feb. 2, 1879, where he received his early education. In 1898 he was graduated with honors from the Ilmenau Technical college. He entered the employ of the Westinghouse company in 1907 as a designer of induction motors. Later he was engaged in general engineering work and in 1912 was placed in charge of design of all direct and alternating-current railway machines. Mr. Hellmund became chief electrical engineer of the company in 1926. He joined the American Institute of Electrical Engineers in 1905 and became a Fellow in 1913.

* * *

AN HONORARY membership in the Engineering Association of Hawaii has been presented to Dr. Elmer A. Sperry, prominent inventor and designer, and past president of the American Society of Mechanical Engineers. This honor came to him as he was returning from the World Engineering congress in Japan. Recently Dr. Sperry, in collaboration with William A. Mayo, chief engineer of the Ford Motor Co., designed an apparatus to stabilize and control automatically the direction of an airplane, thereby relieving the pilot from the necessity of constant attention. Dr. Sperry is noted for his inventive versatility, and since he became interested in the gyroscope about 1896, has made many noteworthy contributions to marine navigation and aerodynamics.

* * *

ELECTION of William B. Mayo, chief engineer of the Ford Motor Co., Detroit, as president of the National Glider association places at the head of that organization an engineer of international repute. Born January 7, 1866 at Chatham, Mass., he is thoroughly trained in heavy duty marine engine and steam power units and is considered an authority on engines of this type. In 1913 when the large combination gas and steam engines were developed by Mr. Mayo and installed by the Ford Motor Co. he became chief engineer of that organization. He also is a prominent engineer in aviation circles and collaborated with Dr. Elmer A. Sperry in the design of an automatically controlled airplane.

* * *

IN HIS new capacity as vice president and general manager, also director and member of the executive committee, John D. Lannon brings to the Brockway-Indiana Motor Truck Corp., Cortland, N. Y., an automotive experience that antedates the birth of the gasoline driven motor vehicle. Prior to the appearance of the first "one lungers," he was with the Locomobile Co. when that organization launched the first steamer. Since those early days of the industry Mr. Lannon has either directly or indirectly designed and built every component part that goes into a motor truck, and has become thoroughly familiar with organization, engineering and production.

* * *

THE career of William L. Cooper, newly appointed director of the bureau of foreign and domestic commerce, department of commerce, has been replete with a varied experience in engineering and design. Three years after he was graduated from the University of Michigan in 1899 as a mechanical engineer he became principal engineer and European manager, with headquarters in London, for the R. W. Hunt Co., Chicago. Later he was advisory engineer for rolling stock for Central Railway of Brazil and consulting engineer to Buenos Aires Central railway for rolling stock, buildings and permanent way. Mr. Cooper supervised construction of the greater part of the rolling stock ordered in the United States by French railways during the World war.

* * *

AT THE annual election of officers of the Society of Automotive Engineers, Edward P. Warner, editor of *Aviation*, was chosen president for 1930. Mr. Warner formerly was assistant secretary of the navy for aeronautics and in addition to his activities in the above organiza-

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WILLIAM B. MAYO
JOHN D. LANNON
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EDWARD P. WARNER

tion he is a member of the American Society of Mechanical Engineers and the Society of Naval Architects and Marine Engineers. Nov. 9, 1894, was the date of his birth in Pittsburgh. Mr. Warner received his B.A. and B.S. degrees at Harvard and during the following two years studied at Massachusetts Institute of Technology. After spending 1919-20 as chief physicist on the committee of aeronautics, Mr. Warner served first as associate professor and later as professor of aeronautical engineering at Massachusetts Institute of Technology.

* * *

A. A. Warner has been appointed chief engineer of the Universal Products Co., Dearborn, Mich.

* * *

E. N. Millan has been appointed chief engineer of the American Rolling Mill Co., Middletown, O.

* * *

Charles W. Esch, chief draftsman in the mechanical department of the Chicago & Alton railroad since 1926, has been promoted to mechanical engineer with headquarters at Bloomington, Ill.

* * *

Richard W. Hautzenroeder, formerly designer and assistant chief engineer of the W. A. Riddell Co., Bucyrus, O., has been appointed chief engineer of the crawler engineering department.

* * *

C. N. Brubaker has been appointed managing engineer of the transformer department of the Erie, Pa., works of the General Electric Co., Schenectady, N. Y.

* * *

Roger Q. Williams, vice president of the Commercial Aircraft Co., Bridgeport, Conn., has designed a five-passenger amphibian plane. It will be produced by the Commercial Aircraft Co.

* * *

Nelson R. Hass, formerly chief engineer of the Grolan Mfg. Co., Dayton, O., has organized the Hass Engineering Laboratory in that city. He is engaged in research and engineering work.

* * *

Charles L. Lawrance has been appointed a member of the advisory committee of the Daniel Guggenheim School of Aeronautics of New York university. Mr. Lawrance is president of the Wright Aeronautical Corp. and vice president in charge of technical research of the Curtiss-Wright Corp.

* * *

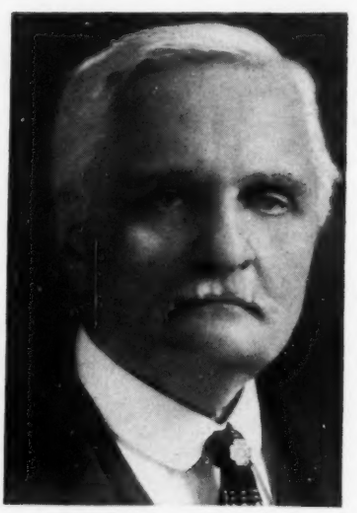
George B. Allen has been appointed director of engineering of the Dodge Bros. Corp., Detroit factory. He formerly was chief engineer.

* * *

Ralph H. Tyler, for 23 years actively engaged in drop forging production in some of the largest forge shops of the country, became affiliated with the hammer department of the Industrial Brownhoist Corp., Cleveland, recently. During his career, Mr. Tyler has been instrumental in inaugurating numerous important improvements in forging equipment.

Obituaries

WILFRED LEWIS, former president of the Tabor Mfg. Co., Philadelphia, and noted as a designer and engineer, died recently and was buried at sea while on a world cruise. Mr. Lewis was born in Philadelphia, Oct. 16, 1854 and received his degree in mechanical engineering from Massachusetts Institute of Technology in 1875. He then became connected with William Sellers & Co., Philadelphia, and in 1883 became designer, serving subsequently as assistant engineer and director until 1900. From that year until his retirement a year ago he was president of the Tabor Mfg. Co. Mr. Lewis became internationally recognized for his inventive ability and his work on the design, construction, and testing of gears. His formula is used as a universal guide in gear design.



WILFRED LEWIS

* * *

Francis Cole Pratt, former vice president and chairman of the manufacturing committee of the General Electric Co., Schenectady, N. Y., died Jan. 26 in New York. Born in 1867 at Hartford, Conn., he was graduated from Sheffield Scientific school of Yale university with the degree of Ph. B. in mechanical engineering in 1888. He joined the General Electric company in 1906.

SPOTLIGHTING THE BUILDER *of the* MACHINE YOU BUY

WHEN you buy new motor-driven machines, some features are self evidently good. Others must be taken for granted . . . leaving their proof or disproof to time . . . meanwhile trusting that the builder knows his business.

But there *are* means for judging whether the builder is up-to-date . . . ways of "spotlighting" his knowledge of the conditions under which, or in spite of which, his machine must produce profitably. One means is a Cutler-Hammer Motor Control installation.

Here is proof that he has done his conscientious best . . . *regardless of cost* . . . to safeguard the motors, the operator, and the machine itself against needless interruptions to production . . . proof that he knows what it takes to produce a fast, safe, convenient-to-operate machine.

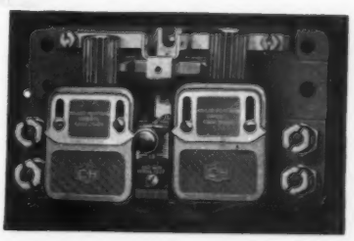
For any motor . . . whether it is built into a machine or purchased and used separately . . . there is a Cutler-Hammer Control to direct and protect it . . . a starter with over thirty years of experience behind it covering every motor control problem of every industry. Standardize on Cutler-Hammer for every motor in your plant.

CUTLER-HAMMER, Inc.
Pioneer Manufacturers of Electric Control Apparatus
1310 St. Paul Avenue
MILWAUKEE, WISCONSIN

MORE USABLE H. P.

The Cutler-Hammer Thermal Overload Relay protects motors so accurately against overloads that heavier loads are handled with safety. And its accuracy is permanent.

Nothing to replace after tripping . . . just press reset button to put motor back in service. It is used on the entire C-H Standard Line of Automatic Starters.



CUTLER HAMMER

The Control Equipment Good Electric Motors Deserve

(A228)

TOPICS OF THE MONTH

A Digest of Recent Happenings of Direct Interest to the Design Profession

OPTIMISM prevailed at the meeting of the Western Retail Implement and Hardware association held Jan. 21-23 at Kansas City. Reference was made by several speakers to the report of the Federal Reserve Bank of Chicago showing that farm equipment sales for 1929 were the largest since 1920 and second only to that year in the period for which statistics are available. More than one hundred manufacturers including about a dozen makers of farm machinery maintained exhibits in the show which accompanied the convention.

* * *

Spring Elasticity Being Studied

Elasticity of mechanical spring material has been the subject of a study conducted by a committee of the American Society of Mechanical Engineers. Experimental work has been carried on for the past year chiefly at Union college under the direction of Prof. M. F. Sayre.

* * *

Fund to Aid Standardization Work

Underwriting of the finances of the American Standards association for a period of three years to permit a total expenditure of $150,000 annually for association work is now being completed, it has been announced by William J. Serrill, president of the organization. This fund permits an increase in the 1930 budget of $80,000 over the previous budget of the association, and is expected to result in the expansion of national standardization work affecting practically all industries. The fund is being underwritten by a large group of industrial organizations.

* * *

Machinery Association Heads Meet

On Monday Feb. 3, the fifth conference of machinery and equipment associations was held at Washington under the leadership of E. F. DuBrul, general manager, National Machine Tool Builders' association. Representatives of practically every important division of machinery manufacture attended the meeting which was devoted to the discussion of the following subjects: Controlling the trade-in evil, uniform cost accounting, establishing normal depreciation rates, time or installment sales, industry statistics, promotion of standards, market research and cross licensing of patents.

During the course of the conference a census was taken of business conditions in the various industries represented. The result of this survey in tabloid form follows:

Road Machinery ..... "Business satisfactory."
Cranes ..... "Noticeable improvement."
Bakery machinery ..... "Normal business."
Diesel engines..... "Orders off slightly; no cancellations."
Dies ..... "Expect normal business by April."
Refrigerators ..... "Heavy inquiry; fair orders."
Flour mill machinery ..... "Heavy inquiries."
Machine tools ..... "Business good."
Pumps ..... "December better than year ago."
Hydraulic machinery ..... "1929 better than 1928 by 20 per cent."
Knitting machinery ..... "Business satisfactory."

* * *

Starter Specifications Drawn Up

Specifications for a starter mounting for small aircraft engines, with a bolt-circle diameter of 4 inches and a distance of 1 11/16-inch from the face of the mounting flange to the clutch jaws, have been drawn up by the aeronautic division of the Society of Automotive Engineers standards committee. Specifications call for six studs with 5/16 by 24 U.S.F. threads. The proposal will be circulated among aircraft engine manufacturers and comments received will guide the division in its future plans.

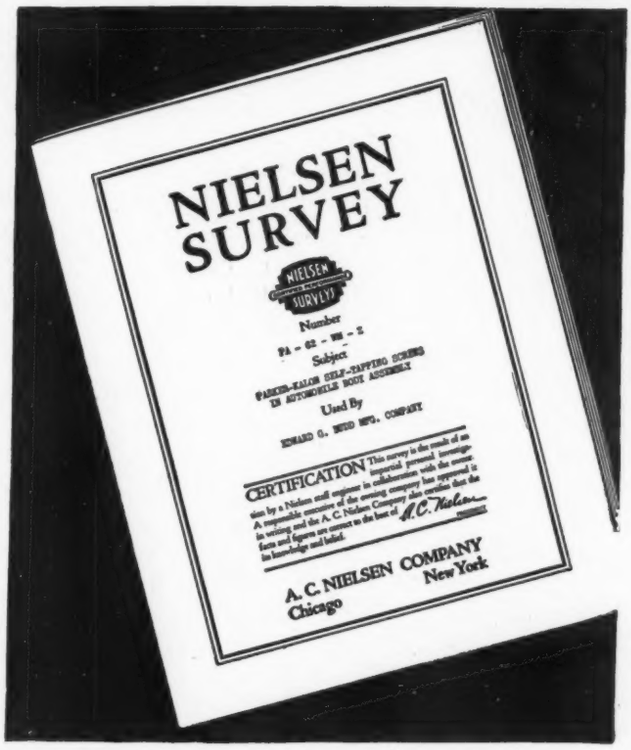
* * *

Auto Shows Reflect Engineering Trends

Now that the 1930 automobile shows have been held from coast to coast, interested observers have been able to form conclusions as to the engineering significance of the new models. The consensus of opinion seems to be that the two outstanding developments reflected in the shows are the 16-cylinder Cadillac engine and the Cord front wheel drive. The latter was described in the October issue of MACHINE DESIGN and the engineering features of the 16-cylinder motor are analyzed elsewhere in this issue.

Other developments of note include the downdraft carburetors, four-speed transmissions, hy-

This Screw saved $152,500 a year on Budd Body assemblies



This Survey tells how

...It will point the way to substantial savings if you assemble sheet metal...Send for a copy

WHETHER you make automobile bodies or corn poppers...if in the assembly of your product you join sheet metal or make fastenings to sheet metal you cannot afford to miss this report.

It presents the findings of an independent firm of investigation engineers who made a thorough study of comparative methods and costs of sheet metal assembly in the plants of the E. G. Budd Manufacturing Co. Every fact and figure is certified by these engineers, and approved by Budd officials.

This report explains why this famous builder of auto bodies replaced machine screws with Hardened Self-tapping Sheet Metal Screws...and how they consequently saved $152,500.00 in a single year.

It describes in detail how these unique Screws eliminated costly tapping operations...abolished the making of tap plates and the welding of these plates to the sheet metal...speeded-up production...simplified and improved mechanical design.

You will find this report chock-full of helpful information on sheet metal assembly. It may point the way to worth while savings in your own plant. We will gladly mail a personal copy to your desk. Just clip the coupon to your letterhead and send it to the address below.

PARKER-KALON CORPORATION
202 Varick Street New York. N. Y.

PARKER-KALON
HARDENED SELF-TAPPING
Sheet Metal Screws

PATENTED APR. 1. 1919 — No. 1299232 — MAR. 28. 1922 — No. 1411184
AUG. 14. 1923 — No. 1465148 — FEB. 10. 1925 — No. 1526183 — OTHERS PENDING

I want to read the engineers' report of the survey made in the plants of the E. G. Budd Manufacturing Co.

Name and Title _____

Company _____

Address _____

draulic chassis lubrication, two-way shock absorbers, improved mechanical brakes and adjustable steel columns.

Numerous critics of the shows note the trend away from six-cylinder to eight-cylinder engines. The popularity of aluminum alloy pistons and connecting rods continues. Rust resistant steels and irons for hub caps, radiator caps and trim are gaining favor. Steel cables are being employed more generally for brake systems.

* * *

Standardization Features Design

It is interesting to note that in the "Wasp Junior," announced recently by Pratt & Whitney Aircraft Co., Hartford, Conn., 80 per cent of the parts are interchangeable with those of the Wasp and Hornet motors. Also the mountings are identical. This noteworthy feature is accomplished by standardization of design.

* * *

Steel Founders to Meet

Plans are being completed by the Steel Founders' Society of America to hold its regular meeting in Cleveland during the week of May 12, 1930, at which time the American Foundrymen's association will be conducting its annual convention and exhibition. John E. Galvin, Ohio Steel Foundry Co., vice president and chairman of the central division of the society, will direct the meeting.

* * *

Turbine Generators Largest Yet Built

Characterizing the increase in volume and dollar value of electrical equipment produced in 1929 over the maximum record of former years, two record size turbine generators were completed and placed in service, according to the *General Electric Review*. One was a 208,000-kilowatt, cross-compound unit and the other a 160,000-kilowatt, tandem-compound unit. Each was the largest of its type so far constructed.

* * *

Tanager Airplane Named World's Safest

Award of the $100,000 prize given by the Daniel Guggenheim fund for the promotion of aeronautics in its safe aircraft contest recently was made to the Curtiss Aeroplane & Motor Co., designer and builder of the Tanager airplane. Features of the Tanager, the world's safest plane include three newly designed safety devices, namely: A floating aileron, automatic wing slots and controllable wing flaps. Slot control is automatic, while the flaps in the back of the wings are operated by a crank in the cockpit. The plane is equipped with oleo and rubber tube landing gear having twice the normal give for a plane of its weight. The Curtiss Tanager was developed at the experimental plant of the company at Garden City and is characterized by its ability to take off and land in small areas.

* * *

Produces 135-Ton Steel Forging

One of the largest steel forgings on record recently was produced in the plant of the Midvale Steel Co., Philadelphia, for the rotor of a 115,000-kilowatt Allis Chalmers turbo-generator. The forging is 42 feet long and weighs 269,000 pounds. When completed the turbo-generators will be installed in the Waukegan plant of the Public Service Co. of Northern Illinois.

* * *

Mechanization Aids Farm Production

Power farming methods have had a vast influence on man's ability to improve his capacity, Prof. R. U. Blasingame, head of the department of agricultural engineering at Pennsylvania State college, declares. During the 10-year period, 1918-1928, farm population in Pennsylvania declined from 30 per cent of the total to 10 per cent. Simultaneously in this period, farm tractors in use increased from 5000 to 35,000, and those engaged in agriculture produced about as much in 1928 as in 1918. In this 10-year period tractors in use in the United States have more than tripled.

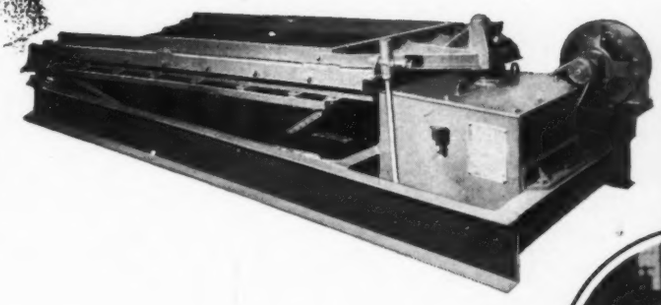
* * *

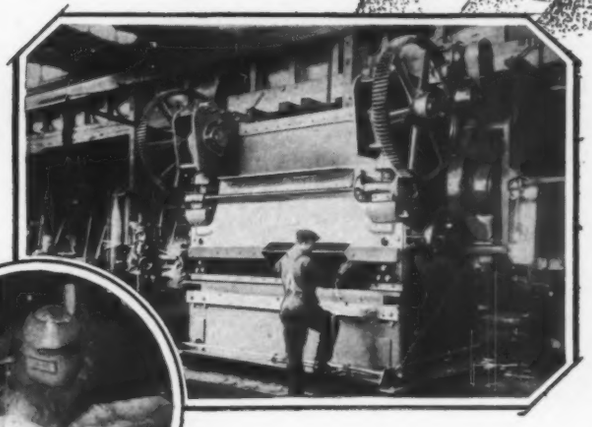
Road Machinery Is Being Improved

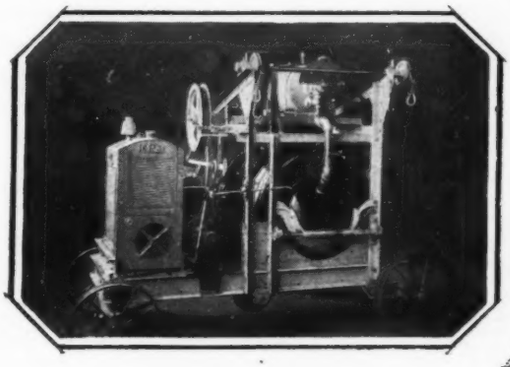
Noteworthy trends toward improvement of machinery for road construction and maintenance were indicated at the twenty-seventh annual convention of the American Road Builders' association held recently in Atlantic City. According to exhibitors, contractors no longer buy machines as cheaply as possible but are purchasing this equipment with an eye to durability and performance. The show indicated that road machinery rapidly is being improved so that in design and construction it compares favorably with passenger automobiles. Already alloy steel is being used more extensively than heretofore and machined steel gears, roller and ball bearings, pressure lubrication and other refinements are generally the rule. Machinery builders also are giving more attention to appearance.

Among the tendencies in design indicated at the show were the popularity of the three-way dump-body, dual drive rear wheels, more general use of self starters, continued extension of the application of caterpillar treads, gradual encroachment of diesel engines in places heretofore occupied by gasoline engines, and higher speeds for many types of road machinery.

RADICALLY CHANGING The Manufacture of Machinery







THE MORE YOU ARC WELD

THE MORE YOU SAVE

Fabrication by arc welding is one of the most outstanding developments in the history of machine design. Small machines in great variety are now completely arc welded. Many heavy machine tools are being redesigned to make use of steel plate and of standard shapes fabricated by arc welding. Special machines may often be fabricated by welding at a cost lower than that of patterns and foundry charges.

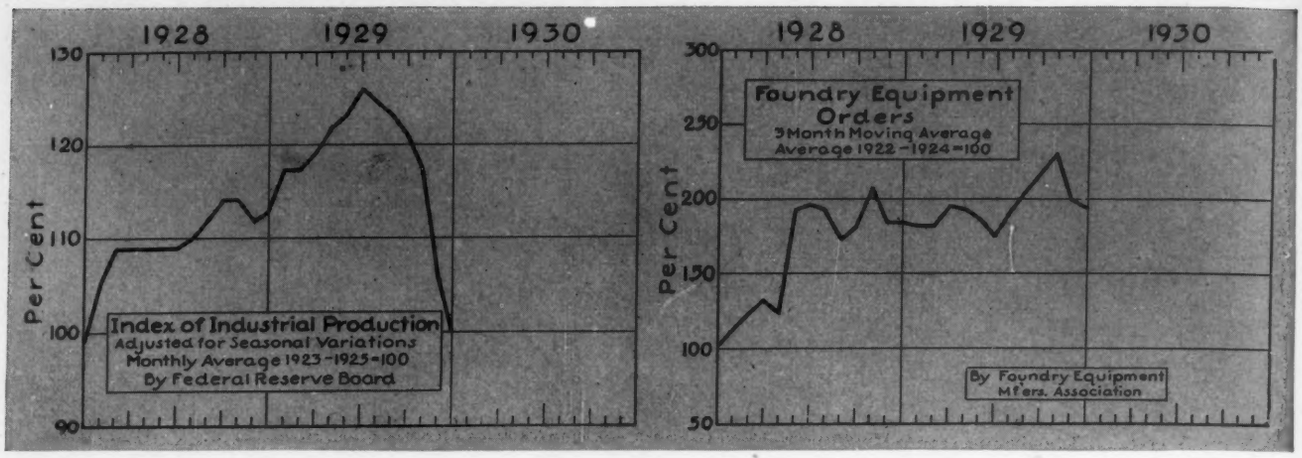
In our own factories, we have made astounding strides in the manufacture of machinery, from the very largest waterwheel-driven generators down to the details of small control units. This has brought us a wealth of experience. This experience, the facilities of our developmental laboratories, and a complete line of arc-welding equipment are available to you through your nearest G-E office.

530-47

JOIN US IN THE GENERAL ELECTRIC HOUR, BROADCAST EVERY SATURDAY AT 9 P.M., E.S.T. ON A NATION-WIDE N.B.C. NETWORK

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., SALES OFFICES IN PRINCIPAL CITIES

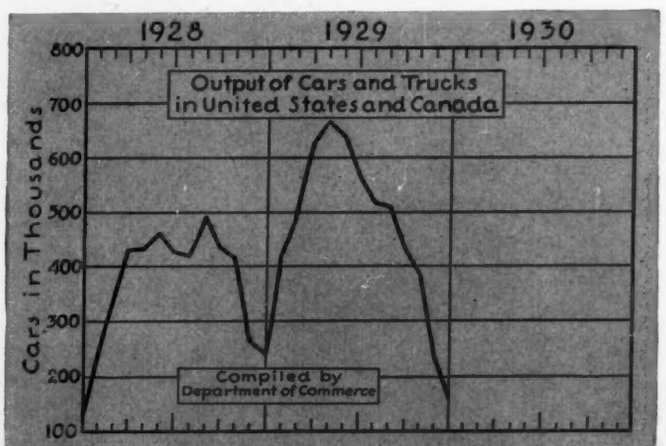


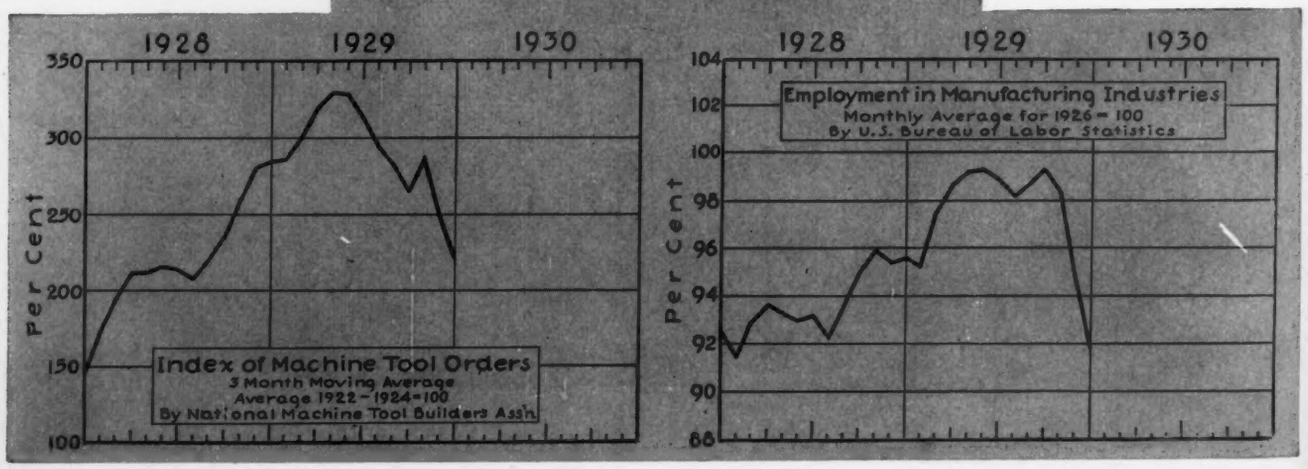
How Is Business?

BUSINESS is on the mend, but the gains are not uniform throughout industry. The sharp recession in production in December, which is reflected in the accompanying charts, has been followed by a moderate upturn in January, which is continuing in February. In general, the revival is more rapid than was anticipated at the beginning of the year.

An encouraging outlook for the machinery industries is forecast by the surprising return to activity of the steel industry, in which operations averaged 75 per cent of capacity during the first week of February. The demand for this material has come principally from the railroad, agricultural implement and automobile industries. Practically all lines of machinery manufacture report good prospects, and in some branches, as for instance hydraulic machinery, present demand is ahead of that in the corresponding period last year. Exports of industrial machinery in 1929 were the highest in history.

Purchases of materials of engineering construction now can be made at prices considerably lower than have prevailed for many months. Steel plates and shapes are quoted at 1.80c to 1.85c, base, Pittsburgh; steel bars at 1.80c to 1.90c, base, Pittsburgh; and cold drawn or rolled bars and shafting (turned, polished) at 2.10c, Pittsburgh. In the steel industry there are signs of the end of the decline, if it has not actually arrived. Increasing activity of mills is lending a stabilizing influence to quotations.





Available for the first time

Detailed Information and Engineering Data on the Flexible Shaft

Every machine designer and manufacturer who has had to meet "around-the-corner" drive problems will welcome this handbook.

He will be vitally interested in the developments that have greatly increased flexible shaft possibilities and widened the range of applications. He will be glad to know about the larger shafts that are now available with correspondingly greater torque capacities,—rugged shafts, capable of standing up indefinitely under the severest service conditions.

This 120-page handbook covers the subject completely. It illustrates and describes a wide range of time-tested and successful applications, every one a direct and simple solution of an otherwise complex drive problem. It details the characteristics and construction of flexible shafts; explains the factors to be considered in making an application; gives torque capacities of the various sizes and grades; tells how to select the proper shaft for a given application; illustrates and describes the various types of shaft couplings and casings; gives complete tables of sizes and dimensions. In short, it furnishes all the information needed to make a flexible shaft application.

How to Get Your Copy

To any engineer, machine designer or executive responsible for machine design, a copy of the Flexible Shaft Handbook will gladly be sent without charge or obligation. We make only this reasonable condition: that your request be made on your business letterhead and that you indicate your position.

Write NOW for your copy

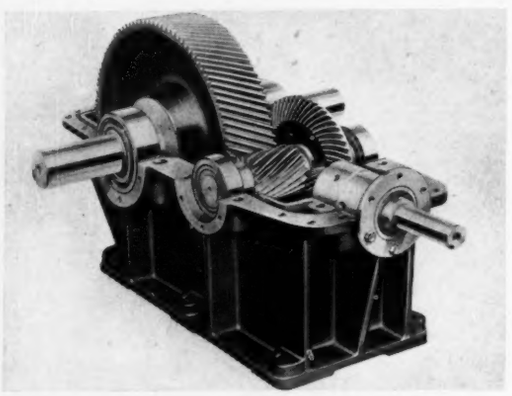
THE S. S. WHITE DENTAL MFG. CO.
INDUSTRIAL DIVISION
154 West 42nd Street, New York, N. Y.

NEW MATERIALS AND PARTS

Worthy of Note by Those Engaged In the Design of Mechanisms or Machines

Designs Right Angle Speed Reducer

A RIGHT angle speed reducer has been introduced by the Falk Corp., Milwaukee, to supplement its parallel shaft drives. The new line includes both horizontal and vertical shaft types. One feature of the drive is a combination of single helical and spiral bevel gears, while another is the reversible construction of gears and shafts.



Right angle speed reducer showing combination of single helical and spiral bevel gears

Ratings range from 1/16-horsepower at 100 revolutions per minute on the smallest unit to 565 horsepower at 100 revolutions per minute on the largest. Ratios are from 1.5:1 to 518:1. A continuous splash lubricating system keeps a film of oil on the working faces of the gear teeth. Welded steel motor beds have been developed to accommodate all motors coming within the capacities of the reducers.

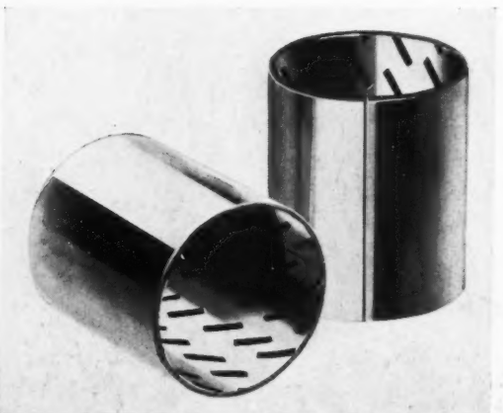
Develops New Type Wire Screen

ANNOUNCEMENT has been made by Ludlow-Saylor Wire Co., St. Louis, of Arch-crimp, a new development in the weaving of wire screens with large openings. The new product is especially designed for severe service on vibrating screens and also is highly suitable for revolving screens. Among the claims for this screen is that tension cannot stretch the wires, abrasion is resisted, and the weave is tight and rigid.

Indentations a Feature of Bearing

IMPROVED results obtained by providing indentations in the bearing metal at an angle of 30 degrees are claimed to characterize the self-lubricating bronze bearing recently announced by the Johnson Bronze Co., New Castle, Pa. The new bearing, said to be the only one of its kind, provides for a uniform area of bearing surface on the pressure line. The compound used also is a Johnson development.

According to the manufacturer, it is only by cutting these indentations that an effective receptacle can be formed for the lubricating compound. This bearing will find application more particularly in machinery and parts subject to intermittent or periodical operation, such as rocker arms, slow running journals, starting motors, landing gears, sliding door rollers and the like.



Indentations seen in the bearing metal retain the lubricating compound. They are cut at an angle of 30 degrees

Controller Has Magnetic Contactor

RECENTLY the Electric Controller & Mfg. Co., Cleveland, announced the development of the Wright dynamic lowering circuit controller in-

SPINDLE RIGIDITY

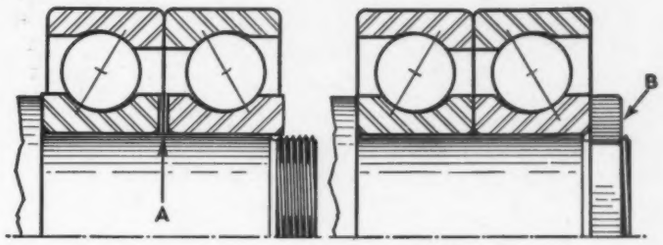


Fig. 1 Fig. 2

How it is obtained with

THE new Hard Tool Alloys have caused Machine Tool Builders to revolutionize spindle construction. The plain bearing with its clearance necessary to maintaining the oil film has given way to the metal-to-metal contact of the anti-friction type. This to secure one result—*Rigidity.*

Rigid spindles must be maintained or vibration and chatter will nullify all attempts to take full advantage of the increased cutting speed of these new alloys.

With this in mind, Machine Tool Builders have been quick to recognize that greater and more lasting spindle rigidity may be had with the Duplex Type of Ball Bearing; not only because it functions efficiently under initial loads *five to ten times greater than can be applied to any other type*—but because it is easiest to install.

GURNEY DUPLEX BALL BEARINGS

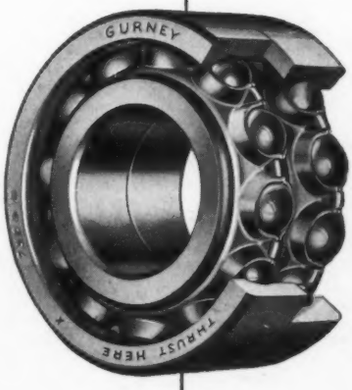


Figure 1, shows a Gurney Duplex Bearing before clamping. The clearance between the inner rings at point "A" is ground into the bearing at the Gurney factory to suit any pre-determined initial load. Installation now merely consists of turning up locking nut "B" until the inner races meet. (See Fig. 2). This simple assembly procedure automatically secures the correct initial load for maximum and efficient spindle rigidity.

Complete engineering information on the Duplex Bearing will be gladly furnished Machine Tool Builders who write the Gurney factory in care of the Engineering Department.

GURNEY BALL BEARING DIVISION

MARLIN-ROCKWELL CORP.

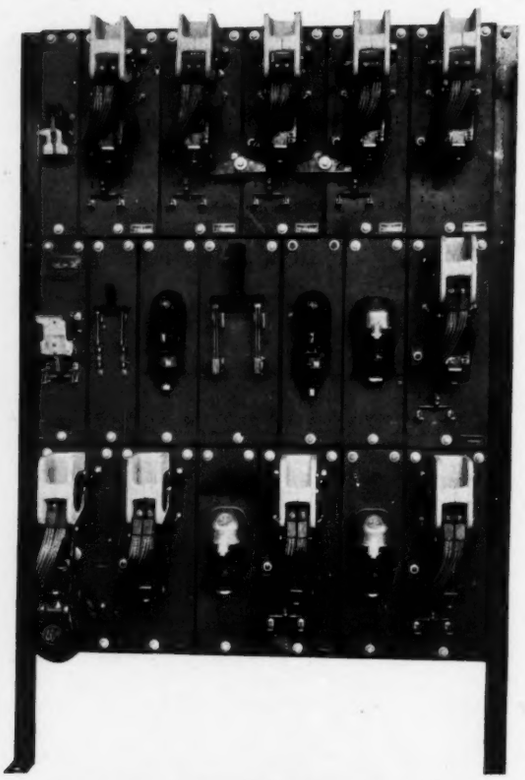
JAMESTOWN, N. Y.

GURNEY

BALL BEARINGS

tended for use on cranes, ore and coal bridges and bucket hoists. Incorporated in the design and construction of the new unit which is of the magnetic contactor type, are features claimed to provide faster speed when lowering light loads or an empty hook.

With this circuit the brake releases instantly. Instead of passing one-third of the line current through the brake on first point lowering, the new circuit passes all the line current through the brake. The accompanying illustration shows the controller which is said to reduce heating of the motor and contactor wear as well as facilitate



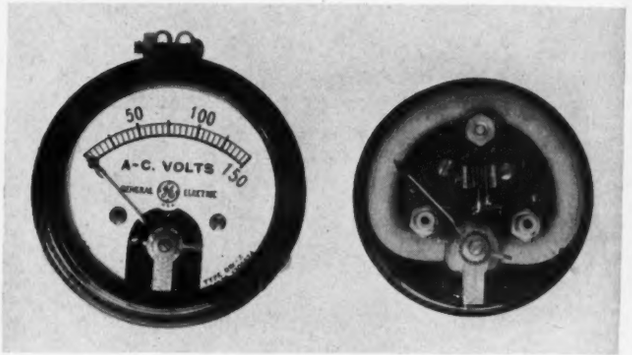
Panel view of the dynamic lowering circuit controller which passes all the current through the brake, releasing it instantly

fewer movements when inching for accurate stopping of loads.

Instruments Made for Low Voltage

SMALL voltmeters and milliammeters, in 2¼ and 3-inch cases, for use on both alternating and direct-current lines have been introduced by the General Electric Co., Schenectady, N. Y. The meters have moulded compound cases and bases, the cases being threaded so as to screw on the base.

These small-size D'Arsonval instruments are equipped with full-wave copper oxide rectifiers

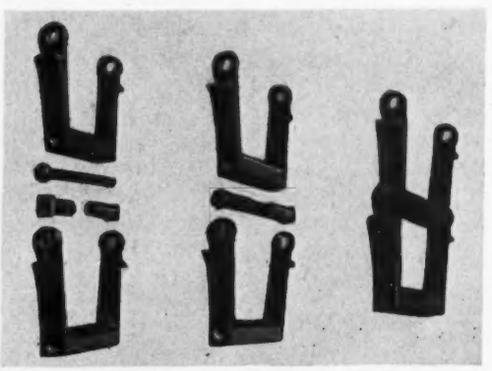


Front and back view of voltmeter adaptable for either alternating or direct current

mounted within the case. The rectifiers permit the instruments to be used on alternating current circuits, and thus make it possible to provide alternating current instruments in low voltage and current rating having the high sensitivity, low power consumption and damping of the D'Arsonval element. The voltmeters are available in ratings from 2 to 150 volts, and the milliammeters in ratings from 0.5 to 15 milliamperes.

Chain Links Are Manganese Steel

A NEW type of conveyor or drag chain, a Brayton patent, recently has been designed and developed by the American Manganese Steel Co., Chicago Heights, Ill. The links are made from manganese steel which is claimed to give better wearing qualities and consequent longer



Evolutionary assembly of chain link showing the two hollow manganese steel bushing pins which increase the bearing surface

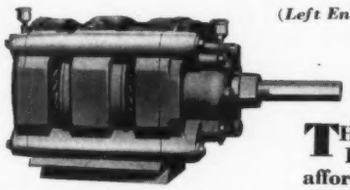
life. Added to this, the design of the pin has been changed materially.

Each link of the new chain is supplied with two hollow manganese steel bushing pins, one

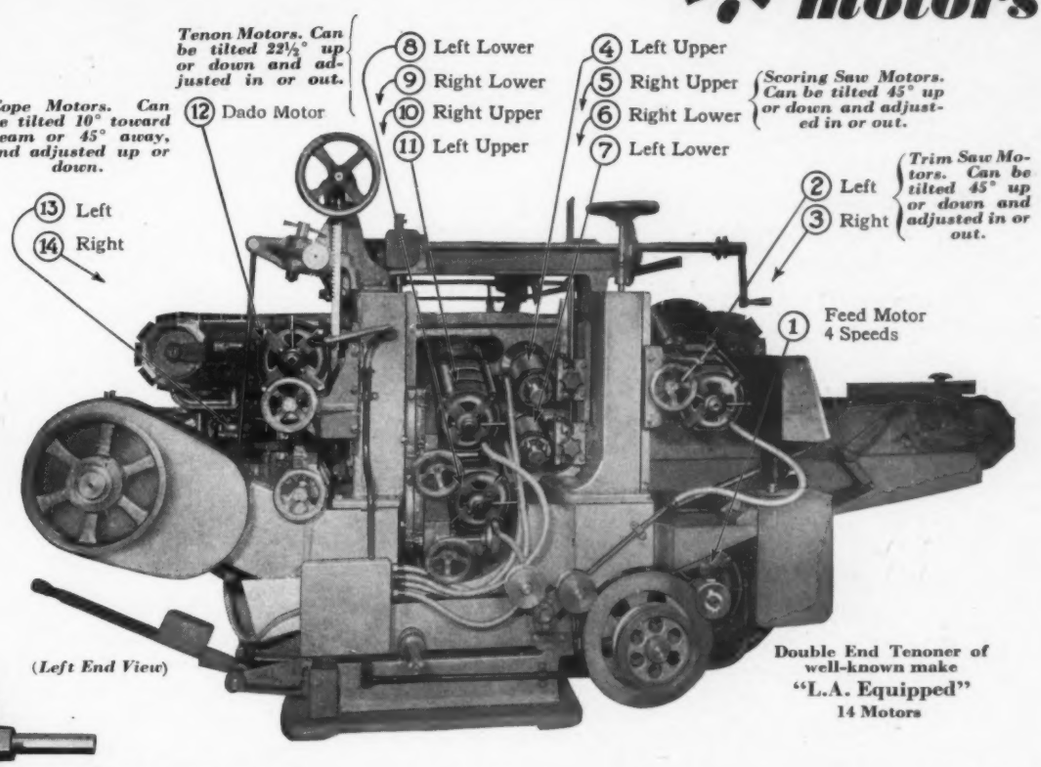
A Study in Modern *Motorization* *with* motors

"Built-in" shaftless rolled shell type motor, as furnished for scoring saws.

4-Speed ball bearing motor as used on feed.



Arbor Motor with extra heavy ball bearings and shaft for mounting trim saw or tenon head. Small overall diameter permits using heads of small diameter. Dovetail foot for sliding adjustments. Cope and Dado motors same except for shaft.


Tenon Motors. Can be tilted 22½° up or down and adjusted in or out.
8 Left Lower
9 Right Lower
10 Right Upper
11 Left Upper
12 Dado Motor
4 Left Upper
5 Right Upper
6 Right Lower
7 Left Lower
Scoring Saw Motors. Can be tilted 45° up or down and adjusted in or out.
Cope Motors. Can be tilted 10° toward beam or 45° away, and adjusted up or down.
13 Left
14 Right
2 Left
3 Right
Trim Saw Motors. Can be tilted 45° up or down and adjusted in or out.
1 Feed Motor 4 Speeds
(Left End View)

Double End Tenoner of well-known make
"L.A. Equipped"
14 Motors

THIS Double End Tenoner—with its 14 Louis Allis "Custom-Built" motors—affords an excellent study in modern motor application. It demonstrates how motors—when "built for the job"—create better performance and greater machine efficiency.

Motors of smallest diameter . . . specially built for operation in any position . . . heavy shafts for mounting cutter heads . . . dovetail feet for sliding adjustments . . . perfect balance at high speed . . . individual control . . . high efficiency and power factor . . . these features of its L.A. "Custom-Built" motors have helped create the *accuracy*, *flexibility*, and *economy* for which this machine is famous in the woodworking industry.

And this example is typical. From both an engineering and sales standpoint, builders of machine tools, woodworking, laundry, ventilating, pumping, conveying, and other modern production machines are finding that it pays to use L.A. "Custom-Built" motors. Louis Allis engineers will gladly cooperate with you in selecting or designing motors exactly suited to your needs.

Write for Bulletins on Louis Allis "Custom-Built" Motors

LOUIS ALLIS

"CUSTOM-BUILT" *Electric* MOTORS

THE LOUIS ALLIS COMPANY
MILWAUKEE, WIS.

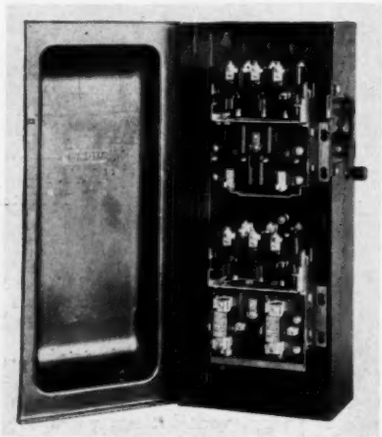
Motor Specialists for 28 Years — Offices in Principal Cities

for each eye of the link. These are held in place by the usual steel pin passing through them in the link barrel. This bushing arrangement enlarges the bearing surface and does away with bowing and distorting. In this new design there is no bending of the pin or bushings and when the chain must be repaired the task is much easier to accomplish.

Starter Has Hand-Operated Switch

STANDARD alternating current across-the-line motor starters equipped with a hand-operated motor circuit switch as required by the National Electrical code, have been announced by Condit Electrical Mfg. Co., Boston. For further security beyond the requirements of the code, both the starter and motor circuit switch will open the same overload.

The starters are equipped with or without fuse clips and meter test jacks, which permit the motor to be tested for load without interfering with machine operation. They are furnished to handle

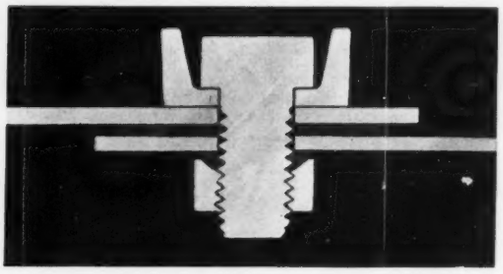


Interior of the alternating current across-the-line starter equipped with a hand operated motor circuit switch

5 horsepower, 110 volts; 10 horsepower, 220 volts, and 20 horsepower, 550 and 440 volts.

New Nut Is Recessed for Gasket

BOLTED steel tank leakage and seepage are claimed to be eliminated by a newly introduced nut provided with a recess in which a small gasket fits. A. A. Kramer, president of the Columbian Steel Tank Co., Kansas City, Mo., developed the idea. By using the recessed nut the packing employed may be punched by machinery, making a clean hole for the bolts. The gasket then is placed over the bolt and pressed into the recess as the nut is tightened, thereby making a



Sectional view showing recessed nut and gasket in tightened position

liquid proof union. The new nuts are furnished either square or hexagon.

Refinements in Blueprint Machines Aid Production of Prints

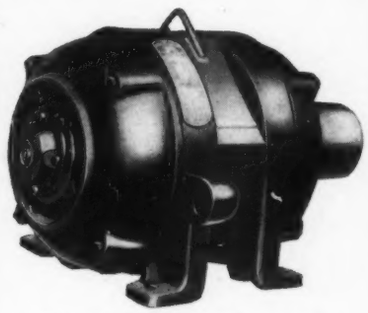
INCREASING interest of engineering departments in efficient production of blueprints is indicated by new equipment being introduced and in refinements to machines already on the market. For the moderate user of blueprints or where emergency prints are urgent, the C. F. Pease Co., Chicago, recently developed the Pease Junior blueprinting unit and sheet washer. Another machine worthy of note because of its improved features is the automatic No. 3-E Revolute unit produced by the Paragon-Revolute Corp., Rochester, N. Y.

The Pease Junior machine requires no special electrical connection, occupies only a small amount of floor space, and consists primarily of a half cylinder of glass supported in a felt-lined metal frame coated with olive green enamel. Tracings and blueprint paper are held in contact with the glass by a curtain mounted on a spring roller. The machine is equipped with the Pease type P arc lamp which consumes 7½ amperes on 220 volts, direct or alternating current. A satin-finished aluminum reflector is provided to give the best possible distribution of light and the drop of the lamp is controlled by a patented cylindrical oil control that provides a regulation for any required printing speed.

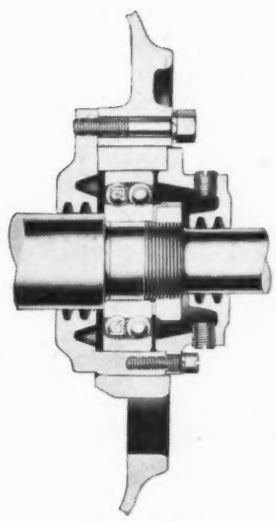
Blueprints in any size up to 24 x 36 inches can be made in one minute with one drop of the lamp, using a clear tracing. With 110 volt direct or alternating current a 24 x 36-inch print can be made in 1½ minutes with one drop of the lamp.

The Pease Junior sheet washer eliminates an

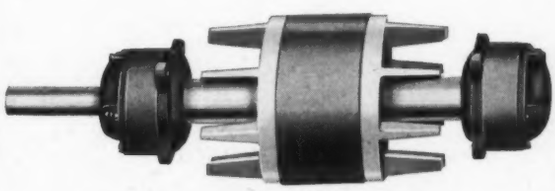
Here's a "line start" motor with important advantages!



Fairbanks-Morse Type QLS (line start) Motor



Self-aligning, double-row ball bearing mounted in sealed shell, which excludes all dirt



Complete rotor showing the sturdy shaft and large, completely sealed ball bearings

Improved design increases efficiency and cuts operating costs

Many manufacturers are now equipping their products with "line start" motors, as this type motor has two desirable characteristics. The starting current is less than that of a standard motor of similar rating. Control is simplified, as no voltage-reducing device is necessary.

In addition, Fairbanks-Morse Type QLS (line start) Motors offer other advantages—important features that will help to sell your product and to build goodwill. An improved type of bearing construction is used in these motors. Self-aligning, double-row ball bearings are mounted in dust-tight, *sealed shells*. Bearings are kept clean *always*, as the rotor may be removed without exposing them to dust or corrosive gases. This construction lowers operating costs by reducing mechanical losses. Shaft wear is eliminated. The life of the motors is greatly increased. Greasing is required but once a year.

Other notable features are permanently plastic insulation, convertible voltage, 220 or 440, electrically welded or solid cast iron rotor windings, and improved ventilation. If you are interested in improved motor performance let us send you complete information about F-M Type QLS Motors. Or, better still, let a Fairbanks-Morse engineer discuss with you the adaptability of this motor to your product.

FAIRBANKS, MORSE & CO.
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32 branches at your service throughout the United States

FAIRBANKS-MORSE MOTORS

1930 begins the SECOND CENTURY of building FAIRBANKS SCALES

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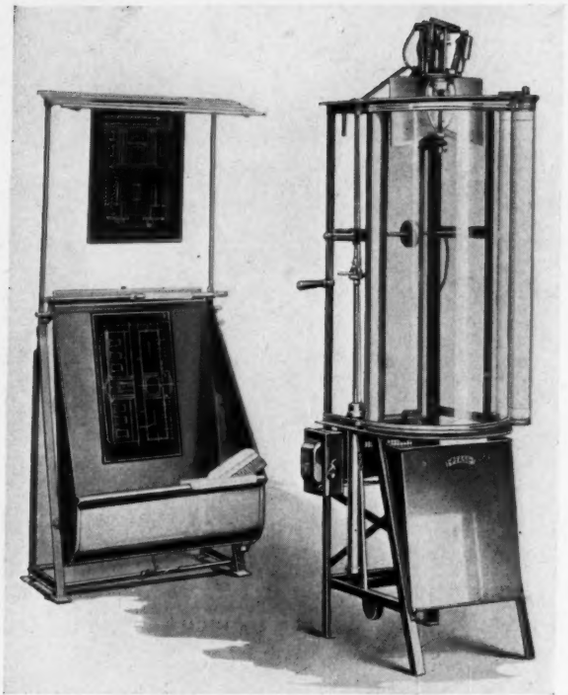

The Pease Junior blueprinting machine and washer designed for the moderate user

open bath tray and dripping prints. Blueprints are washed and dried more quickly than when soaked in a tray and the color is intensified by the use of a 5 per cent solution of bichromate of potash.

A small tray and wide brush at the foot of the washer offer an excellent method for applying the bichromate of potash while the blueprints remain in the washer after the first water wash. Thus the chemical does not come in contact with the hands. After the potash has been applied, a spray of clear water washes off the surplus potash.

IN THE automatic Revolute machine the transparent member against which contact is obtained is a full glass cylinder of pyrex glass which revolves with the belt and mechanism. Tracings are laid right side up on a continuous roll of paper and are carried into the machine by an automatic roll feed and then travel upward and around the cylinder. By this method, prints are exposed to both sides of a bank of pyrex-globed arc lamps. It is claimed that by passing the prints around both sides of the lamps much additional printing speed for a given current consumption is obtained.

Tracings are held in contact by a narrow endless belt the tension of which is automatically controlled and constant unless released by a treadle provided for this purpose. Ventilation of the arc lamp equipped machine is obtained by the use of a squirrel-cage type of centrifugal suction blower, as shown in the inset in accompanying illustration, placed directly against one end of the cylinder. Air from the room is drawn through the cylinder and forced out of a stack or window as desired. This plan aids room ventilation.

Because there is no movement of originals over the glass, causes of static are eliminated, and originals fall into the tracing receiving tray without attention from the operator. Timing of every kind of print is obtained by a variable speed mechanical device, controlled at one point by a numbered dial handwheel which is located at the left of the feeding leaf. The speed variation is from 3 inches to 20 lineal feet per minute.

Washing and potashing in this machine is unusually adapted to high-speed production, the paper being under development for a distance of over 10 feet. Flood and spray washes, both vertical and horizontal, comprise the first clear water bath. The chemical flows directly into the reservoir, a centrifugal pump submerged in this reservoir continuously circulating the supply.

A dryer of the baffled oven type is used. This provides a large evenly heated area and allows the paper to pass through rather than over the heat. It is claimed this reduces distortion. Dryers are equipped as specified for either gas or electric heat. The machine is provided with a special compensator for tension control.

Automatic Revolute blueprinting machine with centrifugal suction blower shown in inset

Take the Cue for Improving Your Product....from this New G. P. & F. Booklet

Somewhere Here You Will Find a Problem that Compares With Yours

THIS booklet has a message for aggressive manufacturers. The message is "product improvement" by methods based on fifty years of varied experience in solving problems of design and redesign.

The opening chapter, "Increasing Sales by Breaking with Tradition," will absorb your interest. It gives a bird's-eye view of the swift changes taking place in the world of goods and things.

You will find much to think about in the chapter, "A Product on the Drawing Board Makes No Profit." You will read how skilled G. P. & F. engineers have saved time and money for thousands of manufacturers by cutting down designing time. You will read why G. P. & F., with a 19-acre plant and unusual production facilities, is such an economical and reliable source of supply for pressed or stamped metal products or parts.

In short, it is fairly certain that in this booklet you will find new ideas for improving your own product . . . new ways to utilize the designing ability of G. P. & F. engineers . . . and new ways to profit by G. P. & F. production capacity and service.

Clip the reminder below for this timely booklet, "In Harmony With Modern Progress." After you read it consult G. P. & F. engineers about improving your own product.

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Clip this reminder for new 1930 Booklet "In Harmony With Modern Progress"

G.P.&F. STAMPINGS

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Please send your 1930 Booklet, "In Harmony with Modern Progress," to the address below. It is understood the writer is not obligated.

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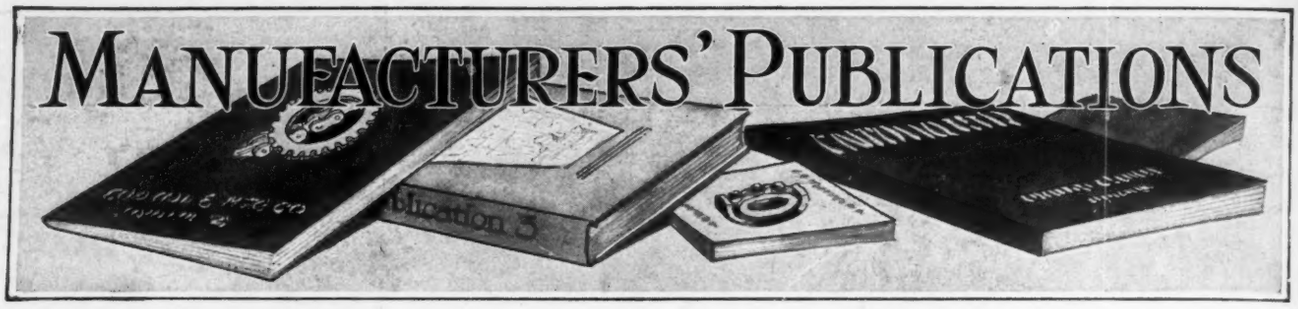

STEEL CASTINGS—Lebanon Steel Foundry, Lebanon, Pa., is distributing a series of bulletins on the subject of its electric furnace steel castings. A folder accompanies them to facilitate filing as future issues are received. The series provide a comprehensive reference on the subject.

CHAIN DRIVES—Link-Belt Co., Indianapolis, recently issued another number of its Link-Belt News. The text covers chain drives in power transmission service, along with interesting descriptions and data concerning various installations of Link-Belt products.

PLANER MOTORS—Heavy duty planer motors for reversing service are described in a bulletin issued by Reliance Electric & Engineering Co., Cleveland. The bulletin also tells what control is required and how it operates. Advantages of direct motor drive are described.

TIME CURRENT CONTROL—Electric Controller & Mfg. Co., Cleveland, has issued a bulletin describing service given in iron and steel plants by its time-current controllers. It is illustrated to show varying types demanded by different mechanical needs of mill equipment.

ROPE DRIVES—A revised bulletin on it rope drives has been prepared by the Allis-Chalmers Mfg. Co., Milwaukee. Illustrations show a large number of installations for various kinds of drive in industrial establishments.

INSULATION—Armstrong Cork & Linoleum Co., Lancaster, Pa., in a current bulletin sets forth the advantages of its corkboard as insulation.

DIE CASTINGS—Superior Die Castings Co., Cleveland, is distributing a bulletin describing its Supercast die castings. Illustrations show a wide variety of die castings for many purposes. A chart of torsion tests of Supercast zinc base alloys also is presented.

STEEL CASTINGS—Special steels for castings to be used under high stresses in oil refining processes are featured in a bulletin by the Nugent Steel Castings Co., Chicago. Various types are illustrated.

PUMPS—Goulds Pumps Inc., Seneca Falls, N. Y., has started a series of bulletins designed to cover the entire line of pumps produced by this company. It is devoted to a series of centrifugal pump selection charts and a description of the company's horizontally-split, enclosed impeller, single-stage, double-suction pumps.

WROUGHT IRON—Wrought Iron Co. of America, Lebanon, Pa., has issued an artistic bulletin to show the lasting qualities of pure puddled iron. It presents photographically a view of an old canal lock in eastern Pennsylvania and an iron bolt taken from its walls after 80 years' service and in good condition. Attention is called to the rust-resisting qualities of this metal.

BEARINGS—"How to Eliminate Ten Bearing Assembly Operations" is the title of a booklet recently issued by Federal-Mogul Corp., Detroit. The interchangeable type of bearing is described and discussed, and suggestions for use in designing the bearing are given.

PRESSED METAL—Geuder, Paeschke & Frey Co., Milwaukee, recently issued a 16-page booklet under the title, "In Harmony with Modern Progress." Attributes of pressed metal products manufactured by this company are interestingly described and illustrated. Better design through the use of its products is discussed. A comparative table of thickness of various sheet metals and their respective gages, and the U. S. standard gage for sheet iron and steel also are given.

MANGANESE STEEL—American Manganese Steel Co., Chicago Heights, Ill., has issued another number of the Amsco bulletin describing and illustrating parts and equipment manufactured from Amsco manganese steel. Fahralloy castings also are discussed. Two additional bulletins deal with Amsco heavy-duty pumps in service.

LUBRICATION—The Texas Co. devotes the current number of its publication on lubrication to the subject of temperature control. It discusses maintenance of the most effective lubricating viscosity. A chapter is devoted to the subject of anti-freeze mixtures for automotive radiators.

WIRE SCREEN—Ludlow-Saylor Wire Co., St. Louis, has just released a 4-page leaflet describing Arch-Crimp woven wire screens for coarse sizing. This new product, it is claimed, forms rigid cylinders or cones which keep their shape until the steel is worn away.

ZINC—A research bulletin has been prepared by the New Jersey Zinc Co., New York, on rolled zinc. Its purpose is to assemble various facts pertaining to zinc in wrought form, particularly rolled. It is intended as a reference book and the index is as full as can be made, to afford greatest value to designers and others.

TRUCK-TYPE SWITCHBOARDS—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., is distributing a bulletin on its truck-type switchboard, designed for ease and safety of inspection. Other advantages of this type also are given.

Business Changes and Sales Notes

Robert E. Kinkead, arc welding specialist and consulting engineer, formerly located at 3030 Euclid avenue, Cleveland, has moved his office to the Builders Exchange building. Mr. Kinkead also has opened a Chicago office at 330 North Western avenue.

Howell Electric Motors Co., Howell, Mich., has announced the purchase of the business of Jeannin Electric Co., Toledo, O. The Jeannin organization manufactured a line of single phase and direct-current motors from 1/30 to 10 horsepower in size. Manufacturing equipment and business of the Jeannin company will be moved to

(*Concluded on Page* 81)

Business Changes and Sales Notes

(Concluded from Page 76)

the Howell plant gradually, so as not to interrupt service to Jeannin customers. This purchase was made without change in the corporate structure of the Howell Electric Motors Co. and combined with the present products of the Howell company, gives a complete line of practically all types and sizes of motors to over 100 horsepower.

Atlantic district sales and service departments of the General Electric Co. at Philadelphia have been moved from the Witherspoon building, which they had occupied for 22 years. The sales and engineering departments now occupy the seventeenth, eighteenth and nineteenth floors of the Mitten building at Broad and Locust streets.

Reliance Electric & Engineering Co., Cleveland, has established an office at 207 Richardson building, Toledo, O. to serve northwestern Ohio, northern Indiana and southern Michigan. C. E. Stine, formerly of the Detroit office, will be in charge.

Announcement has been made that A. R. Sittig of the Chicago Heights plant, American Manganese Steel Co., will make his headquarters at 1176 Union Trust building, Cleveland. His entire time will be devoted to serving the clientele of the company in the Cleveland district.

Wanted

by established manufacturing concern, a machine or line of machinery to manufacture on royalty basis. Plant well equipped for the production of precision machinery. Give full particulars regarding sales possibilities, desired royalty, etc. If services of designer are available, state fully experience and salary expected.

Address Box 100
Machine Design, Cleveland, O.

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MACHINE DESIGN

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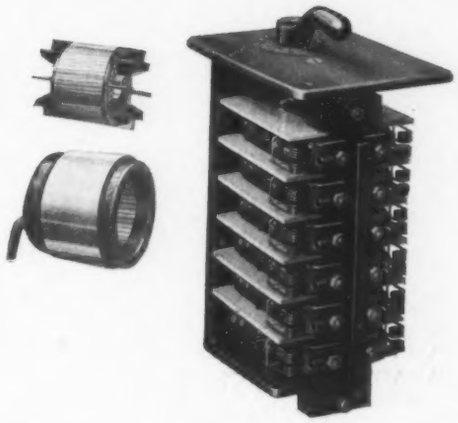
Be sure to give your name and address so that payment can be sent you.

UNION

The Most Complete Line of Squirrel Cage Multi-Speed Drum Controllers in the World

Skeleton Type, Multi-Speed

Drum Controllers



Application. Skeleton type drums are designed to obtain compactness and ruggedness within a limited mounting space. The practice of "building in" a motor is extending to control equipment. The motor stator and rotor only are purchased; the machinery manufacturer supplying the main motor frame, shaft and bearings. The controller is also built into the machine casting, making a custom built design.

Mounting Methods. The machine manufacturer cores a hole in the machine base for mounting the controller within the cavity or builds a box designed to conform to the contour lines of the machine. The cavity can be designed to hold as many controllers as required. The motorized machine is completely wired, ready to operate, with only the connections of the power circuit to be made when installing.

Skeleton type drums furnished for 2, 3, and 4 speeds; constant torque, variable torque, and constant H.P.

For complete details see our illustrated publication 1200 *and* 1200-A

UNION ELECTRIC MFG. CO.

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Manufacturers of

Electric Motor Control Apparatus

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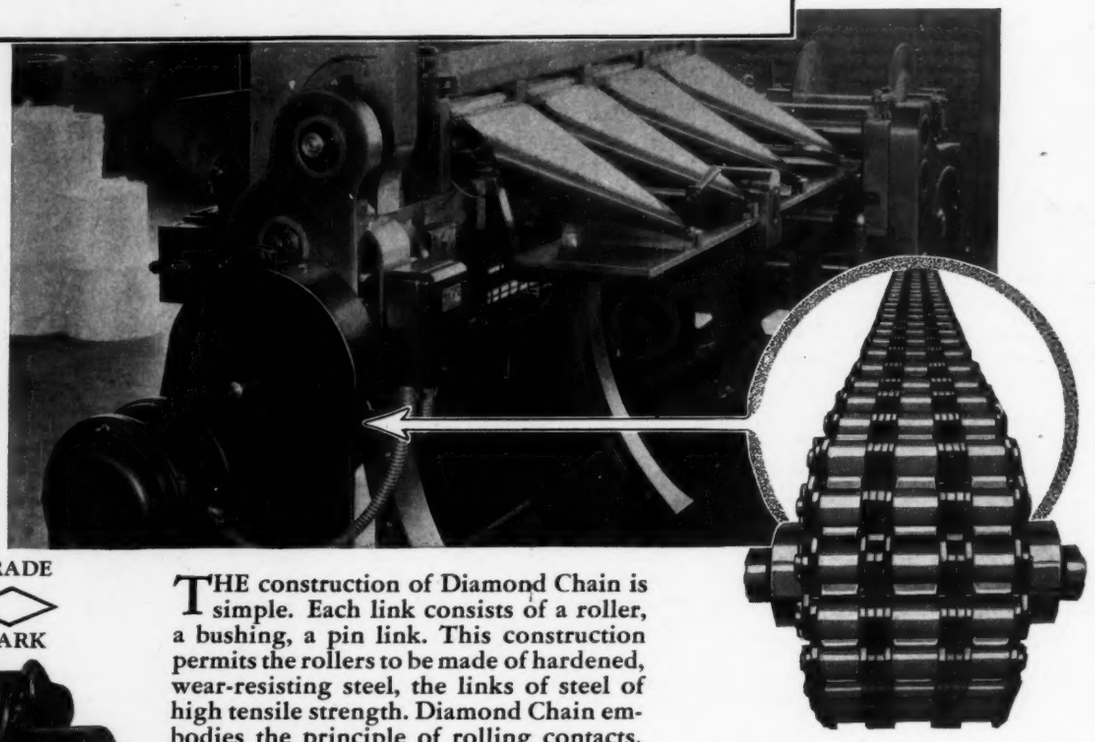
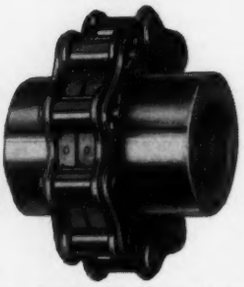
DIAMOND ⟨E⟩ ELECTRICAL MFG. CO., *Los Angeles, Cal.*
Magnetic Motor Control Apparatus

Simple Design *and* Rolling Contacts result in Diamond Chain Long Life



TRADE ◇ MARK



The DIAMOND-CLARK
Flexible Coupling

The Clark Flexible Coupling consists simply of two specially cut sprockets and a length of roller chain. It is made in a wide range of sizes for all ordinary load conditions, for shafts up to 11" in diameter. Its flexibility is in its design and not its material. It permits full freedom of alignment between couplings yet the two halves are held in positive driving connection. The simple, all-steel construction makes for long, trouble-free wear, ease of installation, disconnection and readjustment of drive relation. New Coupling Booklet sent on request.

THE construction of Diamond Chain is simple. Each link consists of a roller, a bushing, a pin link. This construction permits the rollers to be made of hardened, wear-resisting steel, the links of steel of high tensile strength. Diamond Chain embodies the principle of rolling contacts. Each link in this high-speed chain is virtually a roller bearing.

For these reasons and because it is extremely quiet in operation, Diamond Chain has been specified over other forms of transmission on power drives time after time. It resists to a greater degree the conditions which cause breakdowns, production delays and costly repairs. It keeps production up to maximum for correspondingly longer periods.

This positive drive transmits 98-99% of power and 100% of speed. It occupies less space for equal power rating, is equally effective on long or short centers, can be run *over* and *under* sprockets on multiple centers. It is used in single and multiple strands; designed for speeds up to 3600 R.P.M.

Diamond Chain is standardized . . . carried in stock for immediate delivery . . . by distributors in all principal cities. Mail the coupon for a copy of Booklet No. 102A, "Reducing the Cost of Power Transmission."

Diamond Chain & Mfg. Co.,
435 Kentucky Ave.,
Indianapolis, Ind.

You may send Booklet 102A. We are interested in the possibilities of Diamond Chain.

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PHILADELPHIA—Diamond Chain & Mfg. Co., 1011 Chestnut Street.
GREENVILLE, S. C.—Diamond Chain & Mfg. Co., 408 Masonic Temple.
BIRMINGHAM—Diamond Chain & Mfg. Co., 321 Brown-Marx Bldg.
HOUSTON—Diamond Chain & Mfg. Co., 1000 Marine Bank Bldg.

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BIRMINGHAM—Moore-Handley Hardware Co.
BOSTON—Union Gear & Machine Co., 27 Purchase Street.
BUFFALO—Root, Neal & Co., 178 Main Street.
CHICAGO—Cullman Wheel Co., 1344-54 Altgeld St.

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CINCINNATI—Wirthlin-Mann Co., Plum and Commerce Streets.
DETROIT—Palmer-Bee Company
LOS ANGELES—Chain Belt Co., 1414 Santa Fe Avenue.
NEW ORLEANS—C. T. Patterson Co., Inc.
NEW YORK—R. M. Barwise, Inc., 18 Hudson St.
PHILADELPHIA—Robert L. Latimer & Co., 24 to 28 N. Front Street.
PITTSBURGH—Schaffer Poidometer Company, 2328 Smallman Street.
PORTLAND, ORE.—Chain Belt Co., 67 First Street.
SALT LAKE CITY, The Galigher Co., 228 S. W. Temple Street.
SAN FRANCISCO—Chain Belt Co., 909 Harrison Street.
SEATTLE—Chain Belt Co., 1212 Sixth Ave., South.
WICHITA FALLS, TEX.—Wilson Mfg. Co.
MONTREAL, QUEBEC—Williams & Wilson, Ltd.
VANCOUVER, B. C.—Chain Belt Co., 1 Alexander Street

(A-800)